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Monterey, California

THESIS

DISTRIBUTED DATA PROCESSING IN A
UNITED STATES NAVAL SHIPYARD

by

George Thomas Groff

December 1979

Thesis Advisor: N. F. Schneidewind

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Distributed Data Processing in a
United States Naval Shipyard

by

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Lieutenant, United States Navy
B.S.E.E., Purdue University, 1972

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN COMPUTER SCIENCE

from the

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ABSTRACT

The Shipyard Management Information System is a computer-based system that processes data on virtually every element of operations within a United States Naval Shipyard. This thesis examines the characteristics and objectives of a general management information system and the philosophies of the Shipyard Management Information System as envisioned by the Naval Sea Systems Command.

The motivations for, and the characteristics of, distributed processing as they apply to management information systems are presented. It will be shown how an effective distributed data processing system can be created from selective addition of equipment to, and purposeful personnel reorganization of, the data processing configuration at Mare Island Naval Shipyard.

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I. MANAGEMENT INFORMATION SYSTEMS AND DISTRIBUTED PROCESSING

A. MANAGEMENT INFORMATION SYSTEMS

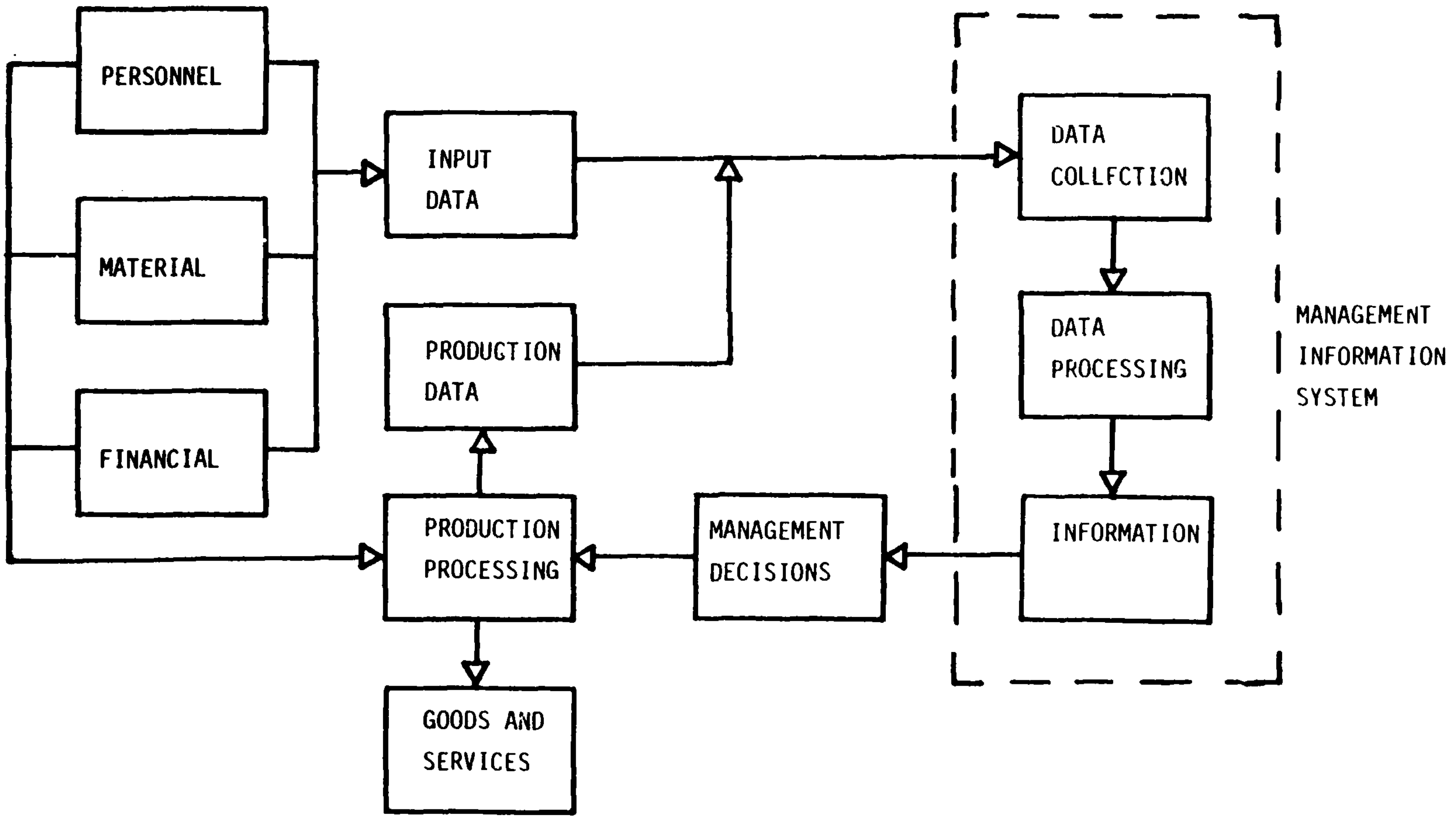
Managers must have complete, accurate, and timely information available in order to make sound business decisions. A schematic model of the relationship between an information system for managers, a management information system, and a production system is shown in figure 1. As demonstrated by this model, the management information system measures attributes of the production system, processes the data, and prepares management information reports. In reality, the management information system is a part of the control loop that maintains dynamic control over the enterprise. The purpose of this section is threefold: to provide a working definition of a management information system; to delineate its general characteristics; and, to list common objectives of management information systems.

1. Significance of a Management Information System

Every business enterprise has a management information system (MIS), however simple it may be. In a two-man partnership in which one man handles production and the other handles sales, each informs the other of developments affecting his own area of the operation. Thus, the firm has an adequate MIS, even if the primary vehicle is oral communication. In a slightly larger enterprise, the management information system may consist of manually prepared records and reports used to control and plan the business. The next level is the use of basic

Figure 1

INFORMATION/PRODUCTION SYSTEM RELATIONSHIP



mechanical equipment to lessen the record-keeping burden and to increase its effectiveness. This equipment may include bookkeeping machines, calculators, and accounting machines. Larger companies require a higher level of both equipment and procedural sophistication. These companies may have a very large computer processor connected to remote field offices, plants, and headquarters by high-speed teleprocessing equipment. The computer complex may record business transactions as they take place, analyze them, feed required support information to all related areas, and service inquiry activity concerning all of the stored transactions. At this end of the MIS spectrum, the operation is expensive, involving an annual monetary outlay in the million-dollar cost bracket. The tailoring of the system to the user's real needs becomes a critical and complex task. Meeting the information needs of management with a poorly conceived system which is either too weak for proper response, or too powerful, and thus too costly, can lead to disaster for the user. Additionally, the use of an advanced information system may determine management's ability to survive in a growth environment. An effective MIS is critical to all business enterprises. Without it, growth is inhibited, and paper work may very well strangle the enterprise.

2. MIS Defined

In most discussion articles, books, seminars, and even university courses concerned with management information systems, there is an initial difficulty in proceeding to the components of an MIS because there is considerable controversy as to the definition of a management information system. Sherman Blumenthal has created a sixteen-part definition of a mangement information system [1] in which a primitive concept (such as: "datum - an uninterpreted raw statement of fact") is defined, and progressively more complex concepts are explained in terms of the simpler, previously clarified ones until a management information system is ultimately defined as consisting of parts of operational functions: "A management information system is an operational function whose parts, corresponding to functional units, are information subsystems of other operational functions." A management information system becomes alternately definable as an operational function whose parts are the management control modules (that part of the information subsystem which supports the management control centers of an operational function) and operational control modules (that part of an information subsystem supporting functional units of an operational function) of other operational functions. This rather imposing synopsis is neither meaningful nor universally applicable.

The Instruction which promulgates the instructions and procedures for the operation and control of the Shipyard Management Information System at Mare Island Naval Shipyard, NAVSHIPYDMAREINST 5260.1B of 2 November 1978 [2], specifically defines a management information system as:

> The combination of personnel efforts, forms, formats, instructions, procedures, data, information and communication facilities related to automatic data processing equipment which providesan organized and interconnected means (either automated, manual, or a combination of these) for recording, collecting, transmitting, processing, and displaying information in support of the functions of planning, directing and controlling the management of an activity as performed by an operational level therein.

This definition, while certainly specific enough for the management information system at Mare Island Naval Shipyard, cannot be universally applied because it is too restrictive.

After analyzing numerous descriptions, applications, characteristics, and attributes of management information system definitions, the following synthesis, as proposed by Walter Kennevan [3], shall serve as the basic definition of an MIS for this presentation:

> A management information system is an organized method of providing past, present and projection information relating to internal operations and external intelligence. It supports the planning, control and operational functions of an organization by furnishing uniform information in the proper time-frame to assist the decision-making process.

This proposed definition of management information can be applied whether the underlying data are compiled, processed and disseminated by manual, mechanical, electro-mechanical or electronic methods. It is also applicable to all systems ranging from the least abstract to those which utilize the most sophisticated mathematical techniques.

3. MIS Characteristics

This definition of a MIS leads to the ten basic detailed characteristics inherent in a management information system. These distinguishing characteristics are that the system: (1) considers the full effect of a decision in advance by supplying complete, accurate, and timely data for use in the planning and decision-making processes; (2) eliminates from the planning and decision-making processes the problems associated with the use of inconsistent and incomplete data by providing a means for preparing and presenting information in a uniform manner; (3) uses common data and methods in the preparation of long-range and short-term plans; (4) identifies, structures, and quantifies significant past relationships, and forecasts future relationships through the use of advanced mathematical techniques in analyzing data, wherever it is appropriate to do so.

Furthermore, the system must: (5) merge financial and production data, and all other pertinent data, to produce significant measures of performance to facilitate control of present costs, and to facilitate planning decisions with a minimum of data processing by utilizing standard data elements; (6) recognize the needs of all functional units so that the requirements of each are met with a minimum of duplication while serving the corporation as a whole; (7) reduce the time and volume of information required to make decisions by reporting to each level of management only necessary detail, and usually only the exception form the standard or norm; (8) utilize personnel and data processing equipment effectively so that the optimum in speed and accuracy is achieved at the lowest possible cost; (9) require that the resulting information be presented to those responsible for the decision-making and planning processes in a form which minimizes the need for analysis and interpretation; and (10), provide for system flexibility and adaptability to change.

4. MIS Objectives

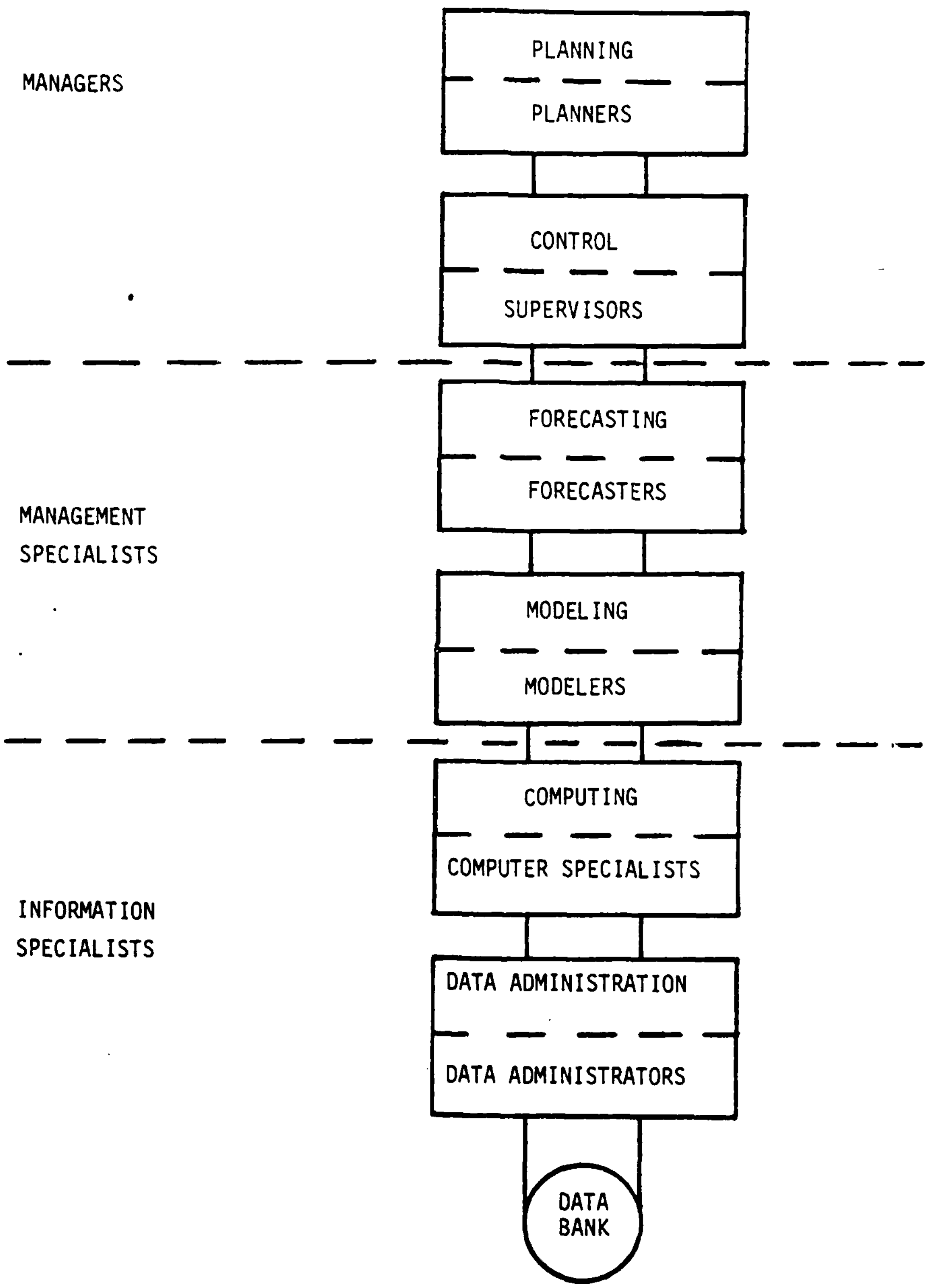
In order to adequately specify the objectives of a management information system, the structure of an organization must itself be understood. This structure cannot be viewed as a static organization that is divided into divisions and departments, but as a dynamic, adaptable system. Within the organization, many processes take place in reaction to the present environment and in anticipation of the future environment. These processes and flows, the resources needed to execute them, and the distribution of managerial responsibilities needed to accomplish the required functions must be understood. Knowing these major forces affecting the nature of an organizational system enables one to translate the objectives of the entire organizational system into the MIS objectives to serve that organizational system.

Since it is true that objectives of different types of organizations are normally different, it can be assumed that MIS objectives of these different types of organizations are also probably different. However, a common link for the management information systems of all types of organizations has been established as described by the seven general objectives delineated below [4]. For a specific organization, these general objectives may require modification in order to make them suitable to the needs of the specific organizational system concerned. The general MIS objectives are: integration of the six levels of a MIS; support of strategic organizational objectives; maintaining the primacy of managerial decisions over machine decisions; the automation of repetitive control functions; the streamlining of the adaptability process; keeping the management information system adaptable; and, keeping the MIS cost-effective.

a. Integrate the Six MIS Levels

The six levels of a MIS and the operational personnel associated with each level, as presented in figure 2, are: the four user oriented levels of planning (planners), control (supervisors), forecasting (forecasters), and modeling (modelers); and the two technological levels of computing (computer specialists), and data administration (data

Figure 2 SIX LEVELS OF MIS



administrators). The managers, management specialists, and information specialists within these levels each employ different jargons, techniques, and data in the pursuit of their goals. Proper integration of an organization through the management information system allows each of these areas to interact with the system in its own terms, and to accomplish its job in the most expeditious manner. At the same time, the MIS acts as a catalyst among these people of diverse skills, and enables them to work on a common project.

b. Support Strategic Organizational Objectives

Strategic objectives of an organization delineate expected achievements over a period of time. Strategic objectives become guidelines for the development of plans for future operations. Strategic objectives are also guidelines for the tools required for the development, implementation, and assessment of plans. The MIS which is planned with the objective of supporting the strategic objectives of the organization, will contain data that assists in the determination of specific types of problem areas and contain models that are appropriate to the forecasts and plans under development. The MIS will aggregate data in a manner allowing the planner, supervisor, forecaster, and modeler to do their best toward reaching the strategic objectives of the organizational system.

c. Maintain Primacy of Managerial Decisions

The purpose of any information system is to supply information to people so that they can make appropriate decisions based on information that is both timely and relevant. This implies that the primary job of a management information system is to aid people in the solution of nonstructured problems which occur in the development of models that are essentially hypotheses about the organizational system to be tested and improved so that they eventually, within reason, resemble the actual nature of the organizational system. Nonstructured problems occur in planning, where problem areas must be recognized, assumptions made, criteria defined, and alternatives evaluated. In the nonstructured problems, it becomes obvious that man must make decisions using the machine as his tool. The machine will do the tedious work of data searching, calculating, summarizing and comparing. Man, on the other hand, must do the creative work: deciding on a course of action, guiding the machine in its work, and evaluating the results produced by the machine. Thus, the manager makes the decisions, not the machine.

d. Automate Repetitive Control Functions

The MIS aids management in the solution of nonstructured problems by removing from the manager's concern much of the repetitive control functions. Since many control functions are highly structured, they are easily automated. This objective may appear to be contradictory to the previous objective - maintain primacy of management decisions over machine decisions. However, this is not so in that the intent of this objective is to automate the maintenance of the database and the comparisons of achieved status versus planned status, and to produce associated outputs. Decisions are not made by the machine, but by supervisory personnel who study these outputs.

e. Streamline the Adaptability Process

Adaptability is a very important characteristic of any enterprise. The organization must be able to recognize and react rapidly to changes in technological and customer requirements. The management information system is able to streamline this adaptability process by employing three major practices: maintain extensive data about external factors which have historically affected the organization, and develop techniques which help identify new trends; maintain the control system in order to be able to ise it for comparison, but allow a planner to insert new goals with which to compare actual results; and, allow a manager to modify any model to include new factors and then gather data to test that model.

f. Keep the MIS Adaptable

One of the best ways of enhancing organizational adaptability is to make the MIS itself adaptable. Although adaptable systems do cost more to initially develop, design and install, the adaptable system will not have to be redeveloped, redesigned or reinstalled. Future changes are relatively easily accomplished at a relatively small cost. Some of the capabilities for change that are included in the typical management information system are: changing of reports or reporting formats; changing methods of data entry or data base updating; modifying specific programs or models; increasing of storage capability by adding additional storage devices of higher capacity and/or speed, or replacement of present storage devices with newer ones of higher capacity and/or speed; and adding terminals to increase the number of time-sharing stations.

g. Keep the MIS Cost-Effective

The objective of MIS cost-effectiveness is to obtain the most effective system for the money spent. This can be done when all other objectives of the organization are described in meticulous detail. Not only must organizational objectives be delineated, but the relationships between the MIS and organizational objectives must be clearly defined and thoroughly analyzed. An important result of this analysis is putting MIS objectives in priority order. Priority is determined primarily by the importance of the MIS objectives that support the objectives of the total enterprise. MIS objectives that support the highest priority organizational objectives are thus found at the top of the objectives list, and the lowest supportive objectives at the bottom. With such a priority analysis, the cost-effectiveness objectives are determined, and the management information system can be acquired that best satisfies them.

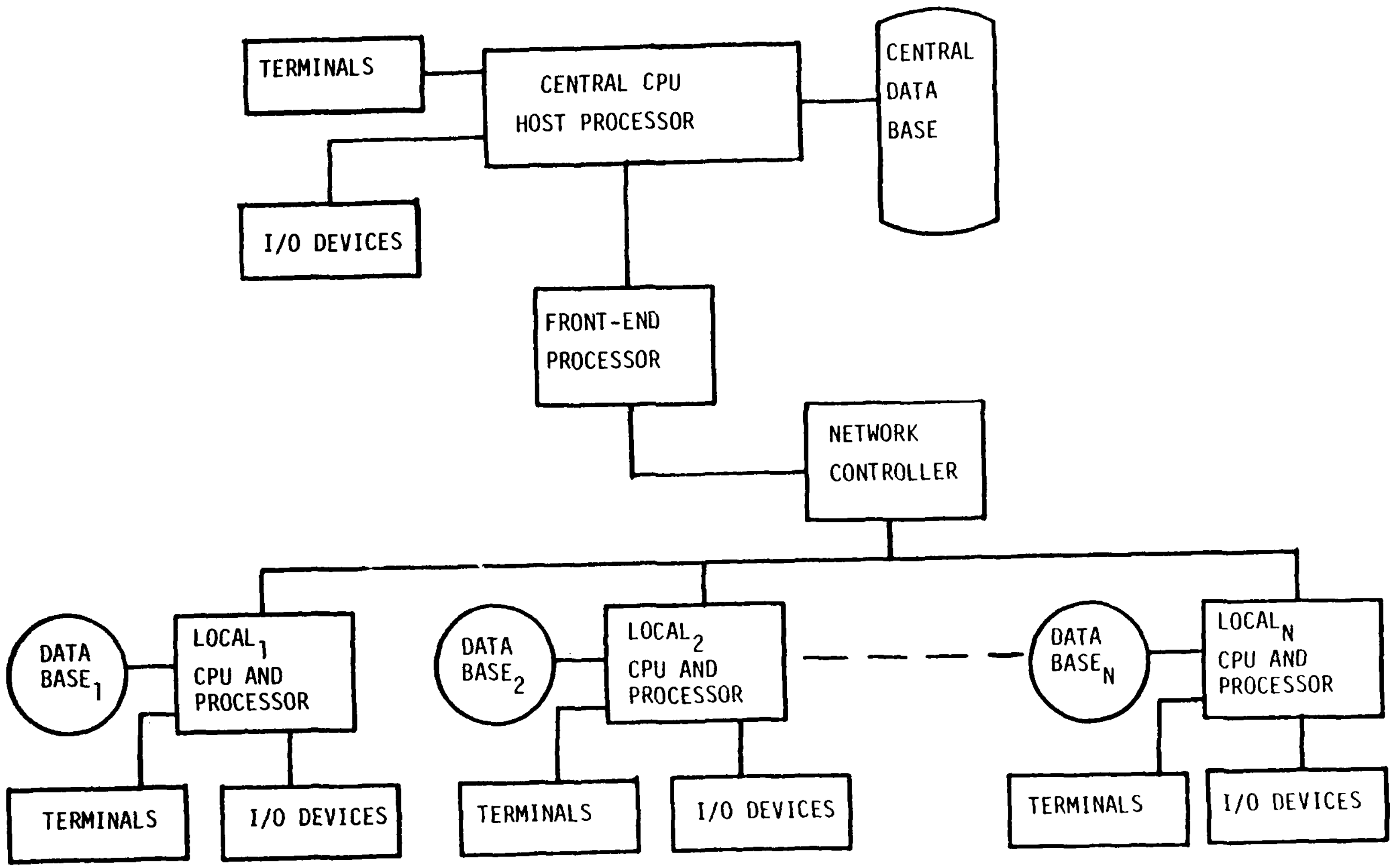
B. DISTRIBUTED PROCESSING

An objective of distributed processing systems is to reduce large data input bottlenecks as well as provide feedback of data necessary to run the enterprise. Distributed processing arose out of the need to get computer power where it is often needed - at the local level A distributed processing approach gives local managers more control over and involvement with their computerized information systems and removes some of the processing burden from the central computing facility. A representative diagram of a distributed processing system is presented in figure 3. The purpose of this section is to present the motivations for, and the characteristics of, distributed processing as they apply to management information systems.

1. Evolution

Prior to the advent of real-time management information systems,

Figure 3 DISTRIBUTED PROCESSING SYSTEM



information systems emphasized historical data. These systems concentrated on producing historic types of reports based upon today's definition of yesterday's requirement. There was very little thought given to the production of relevant information for the control of concurrent operations or for future predictions of operating conditions. These systems were oriented toward custodial accounting, responsibility reporting, integrated data processing, and integrated management information systems [5].

Custodial accounting did not take into consideration a basic need of management - that of feedback to compare actual performance with the desired standard. Manual methods of bookkeeping along with punch cards were utilized to process data in a batch system. No attempt was made to integrate records. Historical reports required lengthy processing time. Access of files was on a sequential basis. Data was primarily used for accounting purposes with output oriented information processing. In summary, a custodial accounting system performed its function slowly and with no great concern for the ability of data processing to aid in the decision-making process.

The preparation of reports on the basis of responsibility assignments evolved from the simple custodial accounting approach. The responsibility reporting system's orientation was toward the accumulation of historical data for a specified time period according to procedures determined by the various activities and levels of responsibility within an organization. It was concerned with activities that were directly controllable and accountable by a particular individual. Although this system made historical reports available more rapidly than did the custodial accounting system, problems still occurred in that the responsibility accounting system was narrow in its perspective. It failed to take into consideration other subsystems within the sphere of the organization - the integration of personnel, production, sales, and inventory, with accounting.

The result of systems designers recognizing that there were more facets to an operation than just accounting, resulted in a logically unified system known as an integrated processing system. Data that was entered into this system was entered singly, as before, but now became available for a multiplicity of uses which transcended organizational and functional boundaries. Elements within a processing activity that were related to other uses were combined into common coordinated procedures which were made possible by having the whole system interrelated. This integrated system was also flexible since the data controlling programs could usually be readily changed as opposed to retraining personnel in the use of new equipment and procedures. Although integration substantially reduced file duplication and allowed for the coordination of major functions with one another, optimum results were still not guaranteed. Control of current operations and the facilities of managerial functions, through a better reporting system, was needed.

An integrated management information system improved upon several of the deficiencies of the integrated data processing system by revising its basic concepts. This basic design provided for decision-oriented information to management that was utilized to assist in the planning, controlling, and evaluating of the activities of the organization. Periodic reports became a secondary feature; information was used more for organizational control and it served several uses and ultimately reduced costs of obtaining essential reports. This integrated management system provided more than a mechanical link between various organizational functions; it provided an automatic means of performing routine decision-making tasks, thus freeing management to perform more complex tasks requiring human thought processes. One important deficiency of the integrated management system, however, was that data had to be accumulated for a period of time before it could be processed. For this reason, all heretofore mentioned systems - custodial accounting, responsibility reporting, integrated data processing, and integrated management information systems - are termed backward-looking systems, since they observe past history before generating reports for feedback. A system that is oriented toward the present, and even the future, was needed - a forward-looking control system.

A trend in information systems is the implementation of real-time information systems, often referred to as on-line real-time systems. Typical applications include hotel and airline reservations, stock market information, law enforcement intelligence, and hospital patient records. The overriding characteristic of this type of system is the on-line real-time concept in which data is sent directly into the computer for processing as soon as it is made available. The real-time aspect indicates that the data is processed into information and returned to the source, or some sort of an action station, sufficiently soon in order to effectively perform a controlling operation on the environment. In order to be effective, the real-time system must have an integrated structure with a data oriented, as opposed to a functional or output oriented, data base since data acquired from one source will serve more than one functional area within the organization. The data base, then needs to be structured in order to satisfy the needs of management, contain fully identified elements in order to serve a variety of purposes without an excessive amount of programming. One deficiency of a real-time system is its inability to provide the information desired by the top-level executives who are responsible and accountable for the full range of all of the organization's activities. Their principle task revolves around strategic planning activities. A real-time information system cannot provide long-range information as such. It can, however, respond with immediate feedback on present operations, which is necessary in order to modify plans. A more recent approach to real-time systems is distributed processing.

2. Motivations for Distributed Processing

In the evolutionary cycle of computing systems, there has been a tremendous dependency on one or more large central processing units to perform the variety of required data processing functions. Bottlenecks are created whenever large amounts of data are simultaneously presented to the same processing unit with resulting undue delays in information retrieval. Distributed processing was formulated as an antidote to that problem in that it has been postulated as being capable of focusing computing power to the location where it was most needed, at the lower levels of the organization. This leads to a system of decentralized executive control. This decentralized control allows for the positive influence of the systems design aspects of extensibility, integrity, performance [6], and cost as motivational objectives for implementing a distributive processing scheme.

a. Extensibility

Extensibility is the degree to which a system's functions and performance can be altered without changing the system itself. Extensibility is also known by its synonyms of expandibility, flexibility, and adaptability. Major benefits of extensibility are ease of modification and ease of growth.

In the sense of modification, extensibility refers to the ease of the replacement of a logical software function, or a hardware element without disturbing its relationships with other elements. Growth extensibility allows for low cost configurations, upgrading of functions and performance in small increments, and low corresponding incremental cost increase.

The decentralized distributed system offers these improvements in extensibility over other systems since boundaries to performance conditions are less likely, or at least less restrictive, than for centralized systems. It will thus be possible to specify a minimum and a maximum system size in conjunction with the number of permitted increments in order to achieve whatever performance level is desired. These increments may very well be incorporated without any changes in the hardware or software design - especially if they are prediced, and allowances made for them, in initial system design.

b. Integrity

The degree to which a system is able to tolerate faults, errors, and failures is known as its integrity. Integrity is also known as fault tolerance, and reliability. A fault is an error generating defect in system mechanics or algorithms. Errors occur when good items of information are turned into failures by the normal algorithms of the system. A failure is an event at which the system violates its specifications. The integrity function involves isolation, diagnosis, and resource recovery techniques which are designed to prevent further damage and restore the system to a satisfactory operating status.

Network resource sharing of a distributed processing system accomplishes the majority of integrity considerations. Decentralization of control also allows for fewer error-producing binding situations between processes and individual processing elements such as processors, memory and communication paths. Much interprocess communication becomes interprocessor communication as a result of decentralized control, this is beneficial from an integrity viewpoint in that detection and diagnosis is enhanced by the mutual cooperation of multiple processors enabling even difficult to discover errors of algorithm design to become more visible.

c. Performance

The most prevalent definition of performance is throughput or response time. A decrease in response time is experienced under centralized control when more processors are added to the system, so that an idle processor can immediately be activated to service a request without suspending other processing or having the request lounge in a queue waiting for service. Even greater benefits can be derived when many processors cooperate in a single job.

d. Cost-Effective

Having several interconnected processors cooperating on one job is also more cost-effective than the utilization of one large processor of equivalent performance. The quantity and functionality of the total smaller processor's logic systems is more readily agreeable to high levels of hardware unity than is that of the larger processor. The latest, most cost-effective technology can be employed in designing and implementing the smaller processors at a relatively rapid rate enabling them to begin functioning sooner than their larger counterparts. Since smaller processors are manufactured in larger quantities, they can benefit from production economies.

3. <u>Characteristics of Distributed Processing</u>

With an understanding of the need for and the motivational factors concerning distributed processing, several characteristics that delineate a system as being a "distributed processing system" need to be described. All of the following should be present to some degree in order to so designate a system: a physical distribution of components; multiplicity of components; a high-level operating system; system transparency; autonomy; an effective communications network; and a distributed data base system.

a. Physical Distribution of Components

The physical distribution phase of the components of a distributed processing system refers to the procedure whereby processors and other integral components of the system are physically separated from each other. This separation may be only by meters, as could be found in a manufacturing application located completely within the confines of one building, or by thousands of kilometers as in the ARPANET application which has intercommunicating sites in Hawaii, the United States mainland, and in Europe. Descriptions that address physical separation of components as the only criteria for a distributed processing system, however, are completely erroneous. Although physical separation forms a part of the definition, a complete description must include the concepts under which physical distribution is in evidence, such as in the physical separation of processing hardware; however, these are not necessarily considered to be distributed processing systems.

b. Multiplicity of Components

A multiplicity of components indicates that the profusion of general-purpose integral parts of the system, including both physical and logical resources, must be present to form a dynamic system. It is not required that the components be of uniform structure; however, they must be available to be assigned to specific tasks on a rotating basis. Basically, it is required that the system have the capability to be able to dynamically reconfigure its resources on a short-term basis in order to provide specific resource services at any specified time. Also, those elements within the system that are not involved specifically with the assignment, cannot have their normal operations affected in any way by virture of the several variations of interconnections throughout the system that may be permitted. The availability of these multiple resources and the capability to interconnect and utilize them effectively and efficiently are highly essential prerequisites for the objectives of extensibility, integrity, performance, and cost control [7].

c. High-Level Operating System

The design of a high-level operating system for the distributed processing system is crucial since it must be concerned with several unique characteristics and problems. In order to properly gain access to the distributed network, the potential user not only must be familiar with the operating system of the equipment he is using, but the operating system of the remote equipment that is to be utilized for the job execution, as well as the overall system operational controls. This is virtually an impossible task due to the general incompatibility of operating systems with each other. It is also a truism that information about the available resources and how to use them is difficult to obtain even for the individual who is willing to learn the specific sub-systems he will be using. Proper design of the global operating system of the distributed network will unify the diverse types of local operating systems, as far as the user is concerned, and present him with only one operating system.

The development of a network operating system (NOS) as an integral part of a distributed processing system is thus essential. The NOS must be a collection of hardware and/or software designed to enable the interconnected computer system to be employed in a convenient, reliable, and cost-effective manner. An effective network operating system is able to assist users to exploit the various resources available in the computer network in a manner analagous to the way in which a local operating system is able to provide a controlled access for its users to its restricted sphere of control. In principle, a NOS is able to provide user services far greater in magnitude than an ordinary operating system because of its "influence and connections" within the distributed system's multiplicity of resources. There is a potential for system degradation, however, if the network operating system places too high of a reliance on system components that are subject to failure, without the employment of an extensive back-up capability. The NOS must therefore be carefully designed so that it makes use of redundant equipment in the distributed system and not fall into the trap of inadvertently reducing, instead of increasing, system integrity. Other, currently active, processing nodes within the system would then be advantageously employed for system back-up upon notification by the network operating system when the need for such processing transfer is required.

In a centralized, hierarchical processing system, the operating system is assumed to have accurate and up-to-date information concerning its operational configuration at any specific moment in time. This may not necessarily be the case in a distributed processing configuration. In fact, it is highly unlikely that truely complete information will ever be available due to the inherent time delay in the collection of status information about the various system components. A conventional processor's operating system is able to request status information of a component and be assured of a reliable answer since that single operating system controls the activities of that single component. The operating system is thus assured that component status will not change until whatever decisions that are required concerning the interrogated componenthave been made. Due to the autonomy of the distributed system (to be amplified later), however, significant time lags concerning status information undoubtedly will develop. Decisions of the NOS that concern a specific device may thus be made and returned too late to effectively alter the operating environment in the desired manner. Inaccurate information begets inaccurate decisions which beget inaccurate actions - a vicious circle that has the potential of negating any benefits of the distributed system.

To further complicate the picture, the possibility exists that different status information will be presented to the different system controlling devices. These variances may occur as a result of time delays in the transmission of status information, the intentional or unintentional shielding of information from the various controllers, or a hideous combination of the two. Network operating systems designers must have, therefore, considered the possibilities of designing the NOS to accept and work with an error filled, inaccurate system status information field. To further complicate matters, most proposed procedures for coping with time delay induced problems, such as voting and software synchronization, also need to be processed by the system which results in further, possibly catastrophic time delays [8].

d. System Transparency

System transparency is that characteristic of the system that provides the user the illusion that he is receiving a set of processes and not processors. The user is able to request a specific service to be provided and not be concerned as to which specific serving device is being employed. The user is able to communicate with the system in the development of routines and programs as though he were using a single centralized system. Communication with the distributed system is normally easier since the NOS software is routinely designed to interface with all the varities of devices, languages, and data definitions available within the system. Since the organization of the system and the knowledge of specific device employment are usually kept from the user, services are requested by name instead of by device. The previous discussion illustrates that a single-processing system could provide the user services if the requisite devices were available. However, the distributed system benefits of extensibility, integrity, and performance probably could not be provided under these conditions.

e. Autonomy

Autonomy of the distributed processing system is that attribute which allows personnel at the local operating level to develop much of their own data processing procedures without continued support and "guidance" from a central controlling station. This autonomy is reflected in both physical and logical operations. Physically, message transmission requires cooperation between both sender and receiver so that hardware operations can continue to perform their assigned transactions even though the centralized controller is temporarily unavailable. Logically, the same degree of cooperation between processes must exist. Unique or critical processing can be handled at the local operating level because of the ease of local program development. Operational activities peculiar to one operating system are able to be accomplished in the distributed environment due to this cooperative autonomy which results in overall systems flexibility. It must be emphasized that this autonomous virtue is not anarchical in nature. All systems components operate under a controlling set of procedures which is reflected in the philosophy of the network operating system. In order to obtain the system benefits of extensibility, integrity, and performance, a high degree of autonomy is required.

f. Effective Communication Network

An interprocess communication scheme is an essential ingredient in the formulation of any computer network or operating system. A "link" can probably best be defined as a union of cooperating processes. It is a general description of a logical communications path in a computer interconnection diagram. Link communications provide the following advantages: uniform communications are possible no matter what the physical separation or configuration may be; all communications are message, as opposed to signal, oriented; the link can be structured so that processes are identified by name or specified directly according to functional classification. Two basic types of link operations are needed - one to put messages into the link and another to remove them from the link. These two routine interprocess communications can be accomplished by the two system primitives, SEND and RECEIVE respectively. Their coordinated operation serves to insure that excessive length messages are not attempted to be terminated early, that proper receipt occurs, and processes waiting for the occurrence of the event are properly activated. Two additional communications primitives, the SUSPEND and RESTART primitives, allow for the special case situations of interrupts occurring in normal operations to service a priority project. These two primitives will, respectively, suspend all activities of the member processes of the interrupted link until the priority project has been finished, and then reactivate the regular processing at the point of suspension [9].

g. Distributed Data Base Management System

Many users are granted access to vast ranges of information through the employment of a distributed data base management system which extends the capacities of computing systems [10]. The organization of the data in the distributed data base system is influenced by the overall function of the system itself, the geographical distribution of the data, and the designer's philosophy. As such, there are several classification schemes available. Geographical distribution of data and directories is one method. Another is by the amound of redundancy in which the data base is either partitioned or replicated. Partitioning refers to the spreading of the data base over several computers, while a replicated system stores some portions of the data base duplicated at various storage nodes within the distributed network.

(1) Redundancy. Partitioning usually involves the division of a very large and dynamic file among several back-end processors within a distributed system. A back-end processor is a computer that performs the data management functions for one or more different computers. Partitioning increases data accessibility, but usually at the cost of more control and communications overhead than is experienced, obviously, with a single file system localized to a single computer. Efficient operation of the NOS software is able to reduce this overhead, however. Redundancy is normally accomplished by locating specific files proximal to the machines that will most often employ them. This method is able to reduce the amount of required intermachine connections, often a limiting factor in the performance of a distributed data base system. Another

benefit of redundancy is that is provides for increased access to the multiple copies of the data, available back-up, and somewhat decreased communication time. Redundancy does impose the tradeoffs of additional cost due to increased storage requirements as well as the increased complexity in normal file updating.

An additional problem experienced by both partitioned and replicated systems due to redundancy is encountered in the cataloging function - information concerning the data base itself. The catalogue, often termed a directory, must be updated whenever a file is created or deleted, a major modification to a file description occurs, and whenever changes to user access permissions occur. This redundancy characteristic of a distributed system imposes additional cost and complexity factors in updating the catalogue due to: inherent communications problems of a geographically distributed data base; the possibility of a broken connection to the main network from a node when operating in local mode which will be relected in out-of-date information for that node; and, similar problems that are encountered when there is distribution of the directories in addition to, or separate from, the data base. A highly efficient network control software system is required to correct the cataloging problem. This software must be able to monitor each node to ascertain when it has gone into a local operating mode and, upon completion of the operation, search it for transactions that may require updating of the system catalogue. A catalogue monitoring program or subroutine also needs to be resident so that each directory can be compared with every other directory to make certain each of them contains reliable information about the data base. Journalizing of catalogue transactions may be necessary during peak operating periods in order to be certain that proper catalogue updates are made.

(2) Data File Allocation. The allocation scheme for data files among the multiple physical storage devices available in the distributed system is one of the problems requiring a solution by the database administrator in order to optimally employ all of the storage capability. In order to accomplish this task, information concerning real, or best-guess, utilization of files is required. It is very often the case that the behavior pattern of file employment is so dynamic that the scheme of file allocation must be inspected with a high frequency to make certain of a continuing optimal allocation scheme. The first step is to allocate files to the back-end processors, and then among the devices associated with each specific back-end processor. Parameters often associated with file allocation algorithms for a distributed data base management system include: the level of data sharing which indicates a partitioned or replicated sharing scheme and, if replicated, to what extent, the nature of the access patterns which may range from query only to extensive updating schemes; and, the information of the nature of the accesses themselves which may be deterministic, have a predictable outcome, or probabilistic, with varying outcomes.

Normal file allocation schemes follow a cost-effectiveness analysis procedure. A generalized costing equation is developed and then various schemes are proposed and analyzed with the intention of minimizing that equation. Total cost is composed of the costs of updating, inquiry, and storage. Any allocation pattern that can reduce one or, preferably, more of these components is desired. Since both the monitoring of file employment and the reallocation of files cost money in memory requirements and software utilization, as well as occupying linkage paths, an optimal balance between the cost of a suboptimal allocation scheme and the cost of reallocation is desired. It becomes obvious that, in a distributed system, the cost of obtaining files residing at other than local network nodes is an important factor to consider. The proper balancing of storage, communication, and data base manipulation schemes is necessary to both reduce costs and enhance extensibility, integrity, and performance.

4. Additional Advantages of Distributed Processing

A large portion of the appeal of a distributed processing system is due to the hybrid approach it offers between the two extremes of the centralized and decentralized systems. It is possible for the distributed system to obtain the best balance between these two alternative types of basic configurations in order to obtain the desired functional requirement. Additional advantages of distributed processing systems can be summarized as follows: powerful processing for application which require a large machine, with full servicing capabilities provided by utilizing a central machine for gross processing services, with inputs and outputs transmitted through the interconnecting communications links. Overall system's efficiency is increased since, tasks for which a large processor is not well suited, such as on-line editing and interface inquiry, can be transferred to the distributed processors for action.

Work can be shifted from an overloaded processor to one which has a lesser demand in order to reduce queue size during peak operating times; the central technical staff can support specialists assigned to projects that are being performed at local processing sites; consolidation of programs and the sharing of common data which provides for system integration of information processing can be completed on the large control unit instead of on the local processors when it is determined to be more cost-effective to do so; organizational activities can be integrated through the exchange of summary data through the organizational hierarchy; users are able to directly control and become more intimately involved with organizational activities in a distributed system; some processing nodes can be dedicated to perform specific processing services resulting in economies of specialization rather than attempting to have each node capable of performing all system services; relatively small sub-systems can result in simplification and additional economy, especially if a mini or micro styled computer is used for the local processing.

Communication cost can be reduced along with the reduced volume of processing since much processing can be accomplished internal to the local processing units without going through a central machine; increased communications efficiency also reduces communications costs since full messages can be stored and then sent at off-peak periods as opposed to sending individual signals as they occur; response time is reduced when interactive functions are performed locally; reliability and security requirements are enhanced by local processing; the prediction and control of costs of the central system can be more accurately accomplished through the use of dedicated processors for local functions; distributed processors are able to share common network software and data bases; central support services can be provided on an on-line real-time basis as needed to the peripheral elements of the distributed system.

5. Pitfalls to Distributed Processing

Although a distributed processing system offers many advantages which were summarized above, there are several potential pitfalls which cannot be called distinct disadvantages, but nevertheless pose demonstratable hazards to the full implementation of a distributed processing system [11]. There is, for instance, a tendency to add additional capabilities to the distributed processor until it almost becomes a system in itself. The specialized function that was initially intended for the local processor is slowly camouflaged by the incremental extensions employed, often under the guise of scale economy and low incremental costs. The specialized node suddenly has evolved into the miniature general-purpose system alluded to, without the accompanying savings of scale normally realized.

A distributed data base management system often is faced with the major problem of data incompatibility especially within systems composed of various software designs incorporated into a heterogeneous network. Variations in logical structures become the problem, and require a data base translation facility. Structural and query translations are the two major components necessary to be adequately solved in order to homogonize the data system. One method of improvement is to include a software package which expresses the relationships between source and target bases and contains a description of system data bases and a translational data definition language.

Interesting security problems are posed by a distributed data base system. It would be beneficial to have the back-end processor screen all requests to the data base. However, since there are no programs resident within the back-end processor, it is impossible to monitor data base activity. A gigantic security liability is inherent in systems which rely on public communications facilities to distribute information, programs, et cetera, to geographically dispersed locations. Current technology is able to easily monitor transmissions between these sites. One recommended solution is to rely upon encryption techniques to preserve security.

Unnecessary system duplication is often encountered if each distributed system project group is allowed to proceed independently in the development of its processing node. Another hazard of independent, uncontrolled development is the possibility that programs and data developed under these conditions may be incompatibly structured for use by the systems. Additional problems within a distributed processing system can be summarized as follows: well-known techniques of systems and processes design may be violated by inept design practices utilized by inexperienced personnel that may be assigned to a local processing unit; development of a sub-process at the local usage level may induce degenerations within the overall system; and, excessive sophistication may be attempted unnecessarily which violates the simplicity aspect desired in a distributed processing system and causes exceedingly complex technical problems that may be difficult to correct.

6. Guidelines For Development of a Distributed System

Generalization of the guidelines to be used in the development and implementation of a distributed processing system are not particularly useful since each system is normally postulated to serve some particular need which is defined by the specific purpose for which it is to be designed. Some general guidelines can be proposed, however, which are applicable across a wide range of circumstances and thus worthy of presentation: the structure of the system must be defined by the master plan. Since independent components evolve from the distributed system, the master plan is an integral procedure to the development in order for each subsystem to focus its attention on where it belongs in the total scheme of things. Structurally, the system can be dimensioned along many different, or a combination of, dimensions such as geographical, commonality of processing functions, functional responsibilities and response time.

a. Simplicity

Significant advantages to a distributed system occur when the components are maintained as simply as the specifications of design will allow. System programs should follow the rules of structured design and be as uncomplicated as possible and still achieve desired results. Data structures need to be designed with transportability in mind. If each distributed component is limited to a narrow scope of functions, simplicity is enhanced. Choosing a system structure that allows for a high degree of independence between the system components and the total system also results in an enhancement of simplicity. Increased independence is achieved by requiring relatively few links accessing each system component, and limited sharing of common data elements. Response time requirements for inter-component communication also influence system independence in that the longer the permitted response time, the greater the resulting independence.

Design tradeoffs occur in deciding whether to design for processing efficiency or cost-effectiveness. A relatively inexpensive system may not be optimum from a processing standpoing and vice-versa. Significant performance and cost variations may be encountered when balancing these two important facets of design in the cost-benefit analysis phase. There are no simple rules-of-thumb or shortcut procedures available to the designer. Careful analysis of each hardware or software performance proposal must be made against economic considerations and the consequence of each alternative solution internally weighed against all specifications before the designer selects a configuration for final implementation.

b. Standardization

Primary orientation of a central coordinating group, who is concerning itself with system design, is to ensure standardized communications interfaces and adequate means for allocating and balancing systems resources are obtained. The following list of matters also need to be attended to by this coordinating group: the provision of a central computing service; the development of integrated applications to be run on central facilities; the development of administrative functions orientated toward the system-wide data base; common application program development; acquisition of technical services to assist in the development of distributed applications; personnel training; budgetary review; hardware selection and approval; hardware maintenance requirements and vendor support; documentation standards; system security; and, priority use standards.

C. PHYSICAL SECURITY

Two major categories of the physical security of a data processing site concern protection from unauthorized access to the computer installation and necessary precautions to prevent accidental destruction of the files and data processing equipment [12]. Prevention methods employed to guard against unauthorized entry during normal working hours include: a receptionist at the entrance to the data processing and storage area; guard service; electric locks; a badge or other identification system; restricted entry policy; and, a pass system to authorize the entrance or exit of materials from the site. Protection methods to be employed after normal working hours include, but are not limited to: guard service including a roving patrol feature; door alarms installed and periodically tested; and, secure door locks in place and in use.

Practices to be taken to detect and/or minimize destruction of equipment and files from disasters include protection methods for fire, water damage, and damage from external events. Fire protection methods encompass: charged fire extinguishers throughout the processing and storage areas and their periodic inspection; installation and testing of fire and smoke detection systems; emergency shutoff switches; and, strict enforcement of "No Smoking" practices. Water damage may be caused by a leaking roof, broken water pipes within the site, and sprinkler system operation. Protection from this sort of damage will entail installation of air conditioning, sprinkler system and building water shutoff valves for the installation, as well as nonflammable emergency equipment covers that are readily available and easily installed. Protection from external events is enhanced by the lack of windows and other accesses from the exterior of the building. Existing accesses must be secured by iron grillwork and have secure window shutters available to protect the site from damage by hurricanes, wind storms, earthquakes, riots and other catastrophic events.

II. THE SHIPYARD MANAGEMENT INFORMATION SYSTEM

A. INTRODUCTION

Information flow within a typical naval shipyard has been placed in a critical position due to the often complex nature of work that is accomplished, the rapid response to and control of work required, as well as ever-increasing costs. In order to effectively manage overhauls whose total budget may exceed $150 million annually, shipyard managers require reliable and timely information in order to enable them to make sound decisions concerning shipyard operations that are both mission and cost-effective. The Shipyard Management Information System (MIS) was developed for exactly that purpose; it provides the shipyard managers with rapid, accurate information to assist in the decision-making process which in turn enables the managers to control resource expenditure over the entire spectrum of shipyard operations. The Shipyard MIS is able to provide the majority of the operational and predictive information needed to monitor productivity [13], provided that the system is applied in the manner under which it was designed to operate.

B. EVOLUTION

The Shipyard Management Information System obviously did not suddenly appear as the answer to the shipyard manager's monitoring and control problems, but had to slowly evolve through a number of years and configurations. The origins of the Shipyard MIS can be traced to the employment of electronic accounting machines (EAM) that were commonly utilized for accounting and payroll applications during and prior to World War II. However, some shipyards further extended the EAM capability to the processes of monitoring job order schedules, personnel skills, and material inventories. When digital computers began to appear in naval shipyards in the early 1950's, these types of data were the ones most commonly transferred to the then revolutionary record-keeping system. The first shipyard computer applications became merely high-speed duplications of the electronic accounting machine system without any changes to the EAM routines.

As each individual shipyard recognized the benefits to be gained from having its own computer in residence, and the funds became available, the shipyard would obtain a computer system. Since no direction or guidance was provided by the Bureau of Ships (BuShips), the forerunner of the Naval Sea Systems Command, each shipyard acquired the computer configuration of its choice, and used it for whatever applications it alone preferred. Thus, it was possible to find a relatively sophisticated financial accounting system at Puget Sound Naval Shipyard, for example, excellent production control at Mare Island, little more than payroll applications at Philadelphia, and a design orientation at Boston.

Prior to 1960, no organized or standardized approach to information processing was to be found in the naval shipyard system. This situation could be partially explained by the different ship-type orientations of the various shipyards. However, regional differences of work force composition and historical influences were also contributing factors. The reasons for the differences not withstanding, the varieties of operations encountered were enormous. Extreme variations of nomenclature also prevailed. A process known by one name in one shipyard would be called something else in another, while the same name could refer to widely differing processes in others. This nomenclature problem was further complicated by considerable variances in the planning, processing, and reporting procedures encountered across the shipyard complex.

A standardized shipyard data management system was initiated by SECNAVINST (Secretary of the Navy Instruction) P10462-7 of April, 1959. This instruction undertook to outline the goals and objectives for the Navy-wide use of automated data processing (ADP) equipment. The use of ADP in the development of budgets, plans, programs, schedules, and other management tools was directed by the Instruction. The use of complimentary and standardized automatic data processing equipment, as well as more centrally developed ADP systems throughout the Navy were also called for.

As a result of SECNAVINST P10462-7, BuShips established a committee to investigate the possibilities of creating a shipyard management information system-like process in compliance with the Instruction. As a result of the efforts of this group, it was decided to develop a standardized management information system for all naval shipyards in early 1961. The system was to be called the Bureau of Ships Management Information System for United States Naval Shipyards. This became the forerunner of the current Shipyard Management Information System.

Various pilot elements of a standard Shipyard Management Information System had been developed by 1962 at the Mare Island and Philadelphia Naval Shipyards. The first standardized configuration was designed by adopting the best available system oriented elements from the individual shipyards and attempting to integrate them into the overall system. The Boston Naval Shipyard assumed the testing site function toward the end of the developmental cycle. Boston's goal was to integrate the components of the system that were developed by the other shipyards into a cohesive system and resolve all interface problems between system applications. At the completion of this initial test, the system was installed in a total of six of ten shipyards who possessed alike computers. Shipyard managers then began to utilize the products of the Shipyard MIS.

Shortly after the system was installed, it became readily apparent that should each individual shipyard be allowed to generate its own program "improvements" or develop its own unique reports, problems could develop with the required systems products. Compatibility between installations would suffer and gradual disintegration of the standardized MIS system would result. In July, 1965, to combat this potential negative aspect, NAVSHIPS, as the Bureau of Ships was now called, established the Computer Applications Support Office (CASDO) and physically located it at the Boston Naval Shipyard. CASDO was able to make the necessary changes to the system that corrected problems not previously revealed by the Boston test. By the summer of 1966, the Shipyard MIS was operational in seven of ten shipyards. Not only did CASDO succeed in solving the large number of the problems involved in the initial design and provide for maintenance procedures of the large computerized system, it also was able to provide in-depth documentation of the system.

By the late 1960's, most of the shipyards had obtained standard computer configurations thus eliminating the initial problem of system implementation. The unique equipment set-up at some yards had led to severe problems. In 1973, a program designed to revise and upgrade the standard system configuration was started since must of the initial equipment was becoming badly overloaded. Newer machines offered more computational speed, more memory, and other innovations such as multiprogramming, real-time data storage and processing, and timesharing. NAVSHIP Instruction 5260.1 of January, 1973, directed the implementation in all naval shipyards of the standard Shipyard Management Information System as it is recognized today.

The computer configuration that was chosen for the new standard system was the Honeywell 6060 which is designed primarily for business applications in the COBOL language, but is able to support other problem types and languages. This was considered to be a large-scale machine employing the most modern technology. The 6060 is constructed in independent module form which allows a user to design his particular configuration to fulfill his immediate needs, yet allow for future expansion. The 6060 is able to support time-sharing, multiprogramming, local and remote batch processing, and real-time processing with each process having access to the same data base.

C. CONCEPTS

The design of the Shipyard Management Information System is based on seven underlying assumptions which reflect the similarities and, to some extent, the differences between shipyard operations and information system design. The following concepts reflect a general philosophy of management information systems with a specific orientation toward shipyard processing requirements: Given the large volume of data flow, an automated system must be employed in order to accomplish the required systematic control and presentation of shipyard infor ation in a low-cost and timely manner; the basic automated system for this information should be standardized in order to satisfy similar requirements for logical solutions to similar problems throughout the shipyard system complex.

The form and structure of this standard Shipyard MIS should reflect the management philosophies contained in the controlling Department of Defense and Navy policy documents, although each shipyard would be allowed some latitude in providing for local requirements; the ultimate users of the output reports, the shipyard managers, should agree upon the format and style of those reports; first line supervisors are to be held accountable for the quality and timeliness of the inputs to the Shipyard MIS: development of raw data, especially concerning frequency of preparation, updates, and refinements, should be totally under local control; and, similar reports should be grouped into families with major differences between reports within a family being the manner in which the information is sorted.

D. FORM AND STRUCTURE OF THE SHIPYARD MIS

The organization of the Shipyard Management Information System closely follows the formal departmental organization of the overall shipyard itself. Since four departments are directly concerned with the actual productive work within a naval shipyard, the Shipyard MIS has been designed to respond to demands for information from each of the four departments through three interrelated functional areas knows as sub-systems. The Planning and Production Departments compose the Industrial Management Subsystem, the Financial Management Subsystem is related to the Comptroller Department, and the Supply Department in the concern of the Material Management Subsystem. These three subsystems are further broken down to a total of eleven functional systems elements known as applications. There are five additional, relatively independent, applications which have been grouped together into an Administrative Subsystem because they support shipyard functions that are not primarily financial, material, nor industrial, but are necessary for complete shipyard operations (see figure 4 with a continuation on figure 5) [14]. The subsystems and their component applications will be discussed in order as follows:

Industrial Management Subsystem

- Workload Forecasting Application
- Production Control Application
- Production Scheduling Application
- Performance Measurement Application
- Design Application

Financial Management Subsystem

- Cost Application
- Budget Application
- Payroll Application
- Accounts Payable Reconciliation Application

Material Management Subsystem

- Industrial Material Application
- Shop Stores Application

Administrative Subsystem

- Radiation Exposure Information Application

Figure 4 SHIPYARD DEPARTMENT RESPONSIBILITIES AS RELATED TO THE SHIPYARD MIS ORGANIZATION

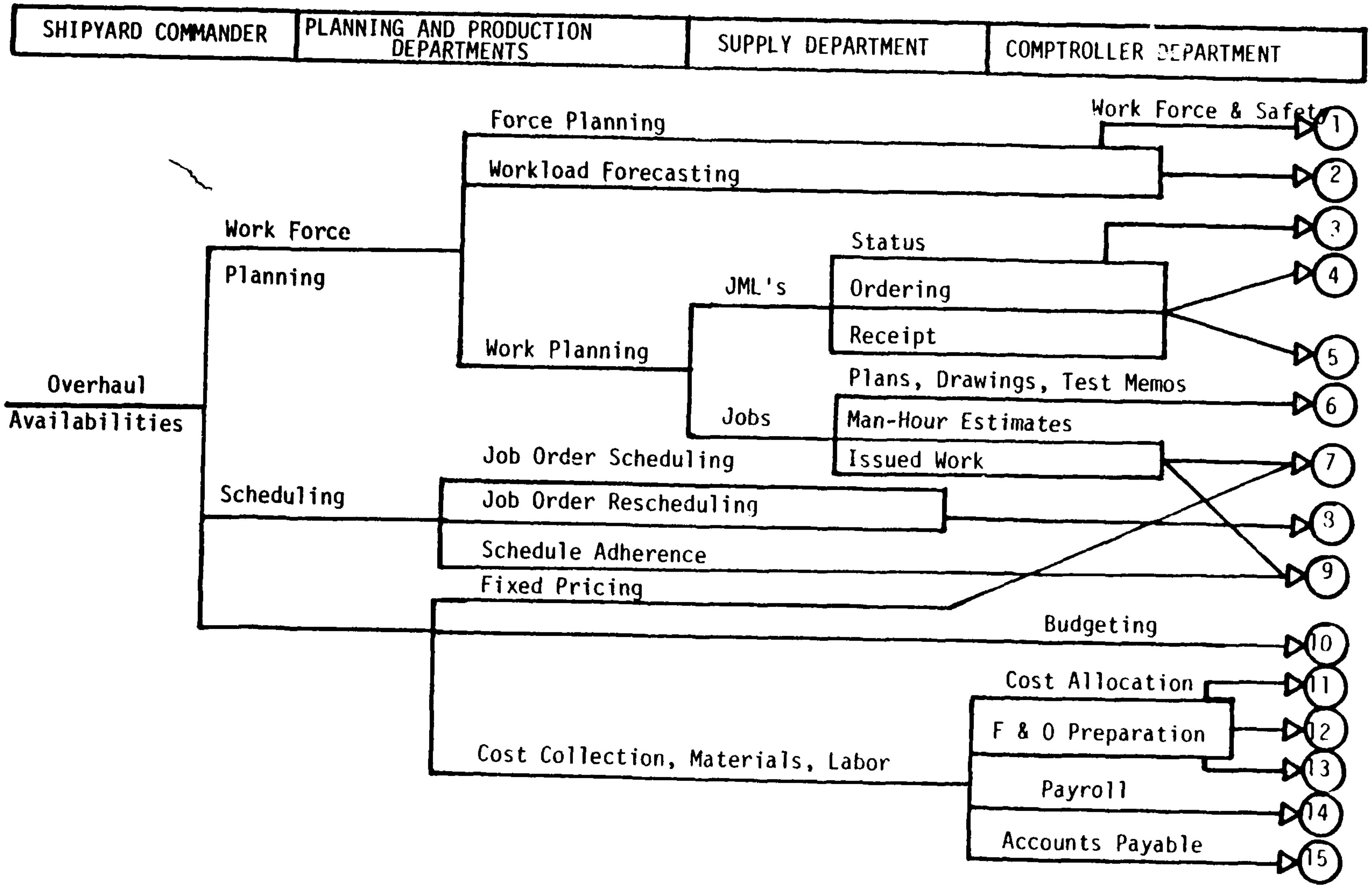
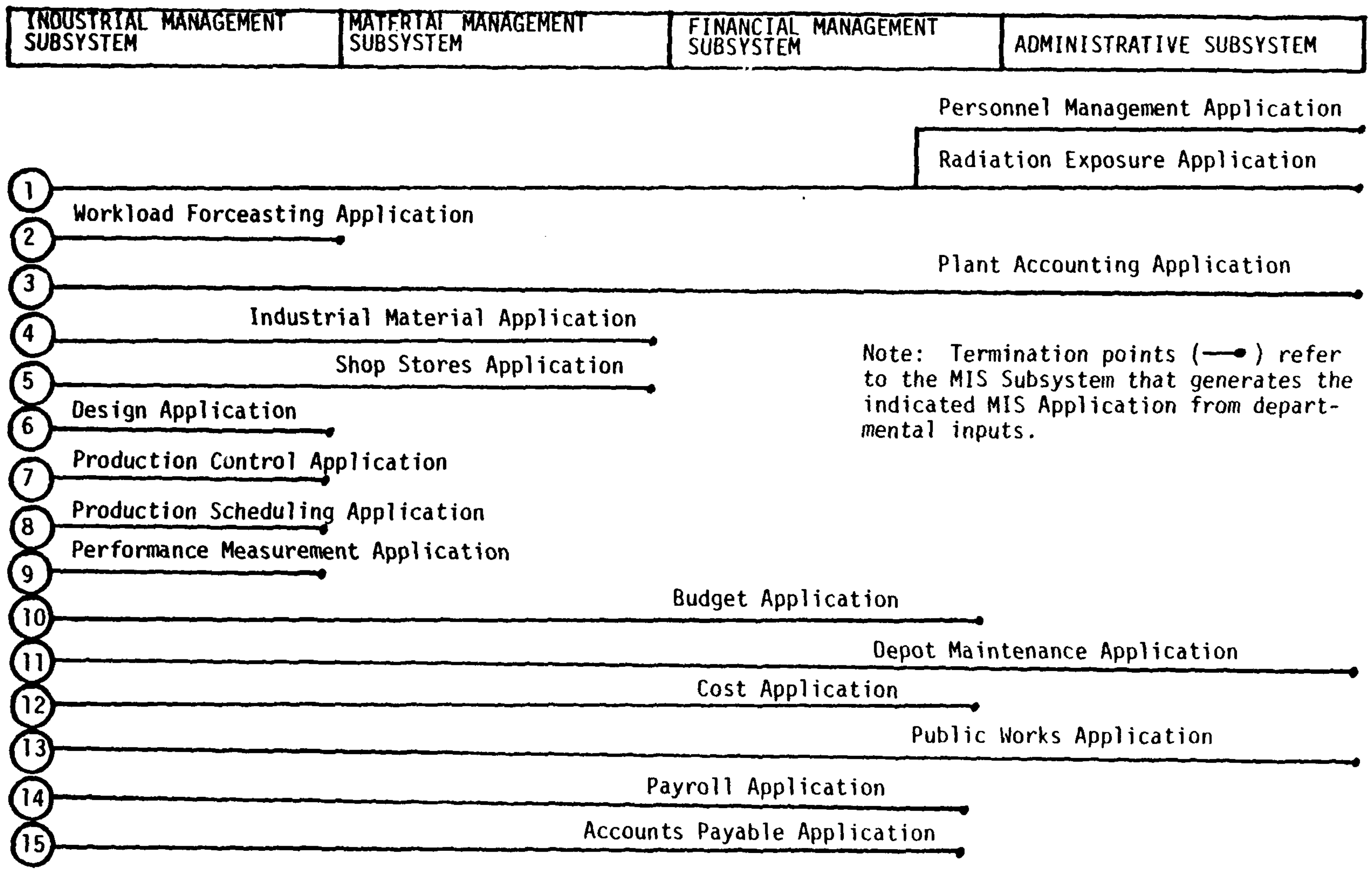


Figure 5 SHIPYARD DEPARTMENT RESPONSIBILITIES AS RELATED TO THE SHIPYARD MIS ORGANIZATION (CONT'D)



Personnel Management Application

Plant Accounting Application

Public Works Application

Depot Maintenance Application

Each application is designed in the form of a logically independent module that is able to communicate data to, and receive data from, other modules through a series of common data bases with each module capable of producing its own set of reports. As a size perspective, the Financial Management Subsvstem is the larqest of the subsvstems since it is required to handle the majority of the routine financial work of the shipyard. The Industrial Management Subsystem is intermediate in size, while the Material Management Subsystem is the smallest.

1. Industrial Management Subsystem

The Industrial Management Subsystem of the Shipyard Management Information System is concerned with maintaining uninterrupted flow of productive work within the shipyard. In order to accomplish this, it addresses the planning and scheduling of work, foreceasts of manpower and material requirements, identification and correction of out-of-control (jeopardy) situations, and evaluation of the results of the productive effort. In order to provide prospective to the structure of this subsystem, and a general picture of the types of information required by shipyard personnel to enable them to make wise decisions concerning shipyard operations, a summary of the shipyard work cycle is presented.

a. Industrial Operations

Since the primary mission of naval shipyards is to perform work in the conversion, overhaul, repair, dry-docking, and to maintain a construction capability for naval ships, it can be accurately surmised that each type of work will cause some variation in shipyard activities. Since an overhaul function is a common denominator for all shipyards, that is the orientation to be taken here. However, before an overhaul can begin, several prerequisite conditions must exist. These are: the ship must be totally dedicated to the uninterrupted accomplishment of the work (availability); the spectrum of the work must be decided, prioritized, and authorized; sufficient funds must be available; and sufficient material and skilled manpower must be committed to the overhaul.

Three major phases of an overhaul are of concern to the Industrial Management Subsystem of the Shipyard MIS: they are the advance planning phase, the short-range planning phase, and the actual overhaul accomplishment phase. The advance planning phase will vary in duration depending upon the type and extent of the overhaul to be accomplished. Normally, this phase is a relatively continuous process extending from two to eighteen months prior to the actual commencement of the overhaul. As decisions are made on repairs and alterations to be accomplished, plans will progress from very rough and sketchy to a more refined and defined form.

The short-range planning phase varies from six to eight months before the time of the ship's arrival in the shipyard until the time it is made available for shipyard work, which is not necessarily the same time. During this phase, preliminary estimations of the man-hours, personnel, materials and cost of the repairs and alterations are accomplished. This information is placed on job orders which direct work to be performed by component key operations called KEYOPS. This phase also includes an inspection of the ship by representatives of the Planning and Production Departments to determine the accuracy of initial estimations and refine any design services and special materials that may be required. An arrival conference is held immediately upon the ship's arrival in the yard to review the scope, priority, and authorizations of the job orders and to finalize the overhaul plans.

The actual performance of the overhaul is the third phase. The Production Department is held responsible for the successful completion of the overhaul. A Ship Superintendent is assigned to each ship to serve as liaison between the ship and the yard and is responsible to the Repair Officer for the coordination and progress of all authorized work that is summarized by the individual job orders. As jobs are finished, the Ship Superintendent will witness the testing of the completed work and obtain certification signatures on the various job orders from the cognizant shipboard department heads. The overall effectiveness of the completed repairs and alterations will be demonstrated by the conduction of appropriate at-sea or dockside trials prior to the departure conference to certify the overhaul completion or to identify any remaining items of work to be postponed, reassigned to ship's force, or eliminated.

From the foregoing summary, it becomes obvious that an effective planning function is critical to the smooth operation of the overall productive work cycle. Planning provides the "bench mark" data required to establish control over the total overhaul. Data that is collected at the start of the cycle includes information on the planning and scheduling of productive work primarily as forecasts of manpower and material requirements. Control over the accomplishment of the work results from detailed comparisons of planned versus actual expenditure of time, labor, and material resources as well as an overall evaluation of the work once it is accomplished. To this end, the five applications of the Industrial Management Subsystem of the Shipyard MIS are designed.

b. Workload Forecasting Application

This application provides three types of significant information to shipyard managers: a forceast of the overall shipyard workload; an analysis of work actually issued to the ships; and an accounting of man-day expenditures performed against the issued work. Each of these elements is also compared against each other as well as to force available information which provides a means of predicting work force requirements. A built-in simulation device allows shipyard managers to test the effects of manipulation of workload and schedules through incorporation and processing of revised data transaction inputs. These adjusted and revised inout factors are processed through the MIS as though they were actual data inputs, the difference being that the output reports are flagged by the transaction codes as potential changes due to the manipulative effects upon manpower and scheduling. These reports are available to a particular shop or to the Production Department on a request basis.

The major files of the Workload Forceasting Application are the Force History File, the Master Workload Transaction File, and the Manning Curve Master File. The Force History File stores transactions relating to manpower availability on a daily, monthly, and quarterly basis; both productive and supportive personnel manpower availability records are maintained and refefenced by ship. The Master Workload Transaction File stores all data on the forecasting methods employed by each shop, work category, for each shipyard requirement; the work start and work completion dates as well as the number of man-days in each workload estimate are maintained. The Manning Curve Master Files stores all data that relates to manning curves employed by the various shops to forecast their individual workload requirements.

Inputs to the Workload Forecasting Application include information on work force composition, job load forecasting and material expenditures. Forceast data are extended to include adjustments based on varying conditions of performance and shipyard loading trends, as well as actual versus predicted cost. The forecast is spread over a time domain through the use of manning curve diagrams provided by the Production Department. Load data, which identifies man-hours scheduled and issued for specific job orders, is an additional input as is the actual man-hours expended on a specific job. This series of inputs encompasses work that is predicted, issued, and accomplished.

Outputs of the Workload Forecasting Application are divided into three report families: workload forecasting reports, which inform shipyard managers of the anticipated shipyard workload by ship and shop; load reports, which present information on work that has been scheduled and issued to the shops; and force distribution reports that provide information indicating actual man-days expended and compare current manning information for forecast figures by ship, shop, and shift.

c. Production Control Application

The Production Control Application of the Shipyard MIS provides for current and valid information on the status of work within the shipyard. In general, this application enables shipyard managers to compare expenditures of manpower and material to allowances and to related schedules. Inputs to the application include scheduled shop manpower loading information, daily direct labor and overtime reports, labor estimates, authorized work listings, scheduled and actual dates for all customer job orders and associated key operations.

The major files of the Production Control Application are the Performance Standards File, and the Performance Schedule File. The Performance Standards File, PROFILE, stores all data that is necessary to compute work center performance by type of measurement standard. The results are then in turn supplied as inputs to the predicted end-cost calculation, and are subsequently transferred to the Performance Measurement Application. The Performance Schedule File stores transactions on scheduled start and completion dates and other scheduling information.

More than fifteen output reports grouped into five report families are generated by the Production Control Application. On-request status reports provide details on the status of all job orders by shop and become a convenient method of assessing what has been allowed versus what has been expended on each job in the shipyard. Direct labor analysis reports provide managers with weekly summary information on labor expenditures by ship and serve as a continually updated prediction on the final anticipated expenditures of direct labor for each ship in overhaul. Jeopardy reports identify potential problem areas in scheduled work areas by indicating which areas appear to be endangering proper job completion, or are being overcharged. KEYOPS scheduled to start/ complete reports enable management to monitor key operations that are scheduled to start or complete within a particular time frame. Production control reports facilitate the monitoring of man-hours issued and man-hours expended versus authorizations.

d. Production Scheduling Application

This application of the Shipyard Management Information System is designed to assist personnel of the Planning and Production Departments in the planning and controlling of shipboard work schedules. Because of the normally nonrepetitive nature of shipyard work, especially as it applies to a specific ship, a formal scheduling procedure is required which permits efficient resource utilization and supports complete performance of all scheduled tasks. The products of this scheduling system are used to assess changes that will be necessary in order to meet schedules, and in determining when schedules cannot be met. PERT (Program Evaluation and Review Technique - used for managing the duration of projects) and CPM (Critical Path Method - used to manage both duration and cost of projects) provide the basic formalized techniques to be used in providing schedules. The scheduling task is accomplished by employing the probabilistic PERT techniques and the deterministic CPM techniques in association with comprehensive formulas contained within the computer programs.

Inputs to this application include descriptions of the sequence and extent of all KEYOPS to be accomplished during the overhaul, estimated and actual start dates, estimated completion dates, changes to job orders, and event and activity data. The Production Scheduling Application is also able to accommodate manually developed schedules and provide for the rescheduling of linear, Gantt-type, schedules based on key events. One major file is employed in the application, the PERT/CPM Master File. This file stores all scheduled start and completion dates calculated by the PERT/CPM formulas, storing them by KEYOP title and key event number.

More than forty-five reports are produced by this application. They are broken down into six report families including error reports, activity reports, event reports, schedule date reports, automatic update reports and automatic rescheduling reports. Error reports are designed to assist the schedulers in the correction of input errors. Activity reports consist of differently sequenced listings of activities contained within the total project network. Event reports are concerned with PERT-type event information relative to a point in time. Schedule date reports provide shipyard managers with the latest changes in project dates. Automatic update reports provide automatic measures of progress for those activities in the overhaul project that may not have a visible progress, as in crew training. Automatic rescheduling reports indicate the results of automatically rescheduling KEYOPS.

e. Performance Measurement Application

The Performance Measurement Application measures the variances between planned work and the results of those plans. The application also processes actual scheduled time and man-hour performance data across the shipyard organization, measured against standards of productive work (engineering, uniform, estimated, and nonstandard) in areas where such standards may exist. Inputs encompass a wide variety of data including scheduled and actual shop workload, Design Division estimates, and scheduled and actual completion dates for job orders and key operations. Two files compose this application: the Standards Usage File, which stores all data and transactions concerned with allowances issued against each of the four types of standards; the Foreman Master and Design Data File which stores data on foremen and design codes, allowances, expenditures for the data period, and design drawing file numbers.

The four families of Performance Measurement Application reports are schedule performance, allowance/expenditure performance, standards issue, and standards coverage. Schedule performance reports provide information on key operations completed, jobs ahead and behind schedule during the reporting period, as well as a percentage of schedule adherence. Allowance/expenditure performance reports provide further allowance versus expenditure comparisons clssified into exception, design, formen, and standards type reports. Standards issue reports compare man-day allowances to the four type of standards and provide a comparison of individual standards allowances with related total allowances. Standards coverage reports present data on total man-hour allowances issued for each of the four standards types.

f. Design Application

The Design Application provides shipyard managers with information which reflects the status of the Design Division's efforts on Naval Sea System Command (NAVSEA) drawings, shipboard service alterations (SHIPALTS), alterations to ordnance equipment (ORDALTS), work items, special projects, and test memos within the shipyard. The application generates current and historical workload data as a basis for determining future manpower requirements, with related allowances, expenditures, and schedules. Inputs to the application include data on man-hour estimates, and actual labor expenditures to locate and/or develop the required drawings, test memos, and special projects.

Three files are utilized by this application: a Master Description File, a Historical Data Update File, and a Master Schedule File. The Master Description File stores data that describe all SHIP-ALTS and work items, including titles and numbers of the documents. The Master Schedule File is the main file of the Design Application, it stores all data and transactions concerned with drawing records including dates of issue and man-hours required to prepare the drawings. The Historical Data Update File stores all transactions concerned with changes made to the Master Schedule File. The Historical Data File also contains histories of all changes to scheduled dates, as well as the date of actual issue of each drawing.

Reports generated by the Design Application include control reports, work package reports, schedule reports, an evaluation report, error listings, and file dump reports. The principal management reports provided by the application are the drawing schedules. These reports list the status of all drawings associated with each SHIPALT and/or work item of a particular ship. The schedule reports also provide the status of all drawings required for any new construction or conversion projects and all test memos that may be associated with a particular ship.

2. Financial Management Subsystem

The Financial Management Subsystem of the Shipyard Management

Information System is concerned with the total flow of industrial money within the shipyard. This subsystem provides controls over basic system inputs, validates charges to job orders, provides for accounting controls over productive and overhead work types, and generates budgeting data for the entire industrial portion of the shipyard. This subsystem is the largest of all the subsystems of the Shipyard MIS, providing more data and generating more reports than any other subsystem. The four applications of the Financial Management Subsystem are all concerned with the Navy Industrial Fund.

a. Navy Industrial Fund

The Navy Industrial Fund (NIF) is a revolving fund established by the United States Congress to provide naval shipyards with necessary working capital. Under provisions of the NIF, a cash allocation is made to the shipyard at the time the fund is established. The fund is replenished by billing customers for work performed, materials supplied, and is surcharged for necessary administration and overhead expenses. The advantage of an NIF is that it provides shipyard managers with a fiscal environment which closely resembles a commercial shipyard activity. Although a naval shipyard is designed to operate on a break-even basis, the key NIF measurement device is the variations between predicted and actual costings which places the shipyard managers in a profit-and-loss situation. Fixed price customer orders become an effect of the NIF on the relationship between shipyards and their customers since these orders establish firm guidelines and incentives for management to obtain performance within limitations of the designated fundings which, theoretically, encourages efficiency and economy. Accordingly, four application areas have been established within the Shipyard MIS Financial Management Subsystem: the Cost Application, the Budget Application, the Payroll Application, and the Accounts Payable Reconciliation Application.

b. Cost Application

The Cost Application accomplishes four major tasks for shipyard management. First, it provides the cost information needed to monitor ship availabilities; second, it provides the expense information needed for the overall financial management of the industrial shipyard; third, it collects the data required to generate the shipyard Financial and Operating (F & O) Statements; and fourth, it provides the means by which requests for additional cost data from NAVSEA Headquarters, other Navy commands, and the Department of Defense can be answered. The Cost Application is the largest application within the Shipyard MIS and processes an enormous amount of detailed cost accounting transactions daily, primarily to shipyard ledger accounts.

Along with accepting transactions utilized within its own interest area, the Cost Application provides a wide spectrum of information to other applications. It receives raw man-hour expenditure data and transfers validated man-hour expenditures to the Production Control Application's PROFILE; it receives dollar data on materials and provides them to the Industrial Material and Shop Store Applications of the Material Management Subsystem; and it receives planned and work-in-progress man-hour data and provides them to the Workload Forecasting and Performance Measurement Applications of the Industrial Management Subsystem.

The major files of this application are the Cost Master File, Validation Control File, and Transaction Master File. The Cost Master

File stores a summary of all transactions that are related to the cost of labor and material for productive work in progress by job order and shop, and includes data on overhead expenses. The Validation Control File contains basic data on the Customer Order Acceptance Record (COAR), plus control numbers which indicate the desired level of validation for charges, these control numbers allow for labor and material charges to be validated to the control number, KEYOP, shop, and work center levels as dictated by NAVSEA, and as augmented by local policy. The Transaction Master File stores transactions concerned with unallocated costs, as well as the multitude of other daily transactions that are concerned with the updating of shipyard ledger accounts; examples are charges to work in progress, summaries of one-time charges, force data for NAVSEA reports, and price variance data.

The Cost Application of the Shipyard MIS generates one-hundred and ten reports distributed among three report families. The families are: customer order reports, unallocated cost reports, and expense reports. Customer order reports are the major funds controlling devices employed by the Planning Department. The status of dollar expenditure for each customer order is provided and enables an accurate prediction as to the ultimate overhaul labor costs by ship. This family also provides a report which can be used to detect potential cost overruns in time to permit corrective action. Unallocated cost reports provide shipyard management with costing information that has not been specifically assigned to a billing account. Expense reports provide comparisons of actual charges to productive and general expense centers versus budget. Comparisons are shown in dollar values as well as man-day amounts. This family of reports provides the information needed to continuously monitor expenses and to detect trends, thereby providing a tool to help control cost and remain within budgetary constraints.

c. Budget Application

The Budget Application is the smallest application of the Shipyard MIS. This application is concerned with: the generation of data to budget all shipyard work loads and yard-wide overhaul expenditures; monitoring of the availability and adequancy of operating capital; and summarizing loans and capital transfers for the reporting period. The Budget Application employs the budget worksheets as the primary input transaction element. The Budget and Statistics Division of the Comptroller Department is the principle user of output information from his application. Seven reports are generated which summarize: labor outputs by department; labor transfers between shops; employee leave; budget estimates for overhead by work centers, departments, and common group cost centers; as well as providing budget estimates of total labor and materials.

d. Payroll Application

The primary purpose of the Payroll Application is to accomplish timely and accurate payment of all naval shipyard employees and to generate all of the reports required by shipyard managers to control and audit pay and leave accounts. A secondary purpose is to enable compliance with the many Department of Defense and Navy directives concerned with naval shipyard payrolls. The application may also serve tenant and satellite activities in the management of employee leave, payroll savings and bond programs. In accomplishing these tasks, the Payroll Application establishes a payroll record for each employee withich includes personnel identification data, rate of pay, and payroll deduction data. A Dailv Clock Card for each employee is processed as input, and records his hourly charges or absences. The data is converted to labor and leave dollars by the application which in turn stores the information for future use in developing the payroll.

There are four files employed within this application: the Pay, Leave, Bond, and Financial Institution Master Files. The Pay Master File stores all historical earnings data of all graded and ungraded employees and is updated daily by the Daily Clock Card. This file also contains a complete pay account for each employee. The Leave Master File contains the employee leave accrual and usage records. The Bond Master File stores payroll savings data and deduction instructions for United States Savings Bonds. The Financial Institution Master File stores the addresses of institutions which employees have indicated are to receive their allotments and/or net pay. In addition to the use of payroll data for pay purposes, data on man-hours and dollars stored in the Payroll Master File are transferred to the Cost Application and then to the Production Department's PROFILE for Production Control, Workload Forecast, and Performance Measurement reports.

More than eighty different reports are produced by the Payroll Application. Five report families are represented: control reports are used to preserve the integrity of the timekeeping and labor reporting functions; audit reports provide the means to review and trace all payroll data; payroll savings reports present data on the progress of U.S. Savings Bond sales and savings allotments of full-time employees;

service reports include the actual paychecks themselves plus annual withholding statements; and management information reports present statistical data on the payroll.

e. Accounts Payable Reconcilation Application

Shipyard funds management requires an entry in the accounts payable account whenever Navy Industrial Fund material is received, and an entry in the material-in-transit account whenever NIF material is paid for prior to its actual receipt. The purpose of the Accounts Payable Reconciliation Application of the Shipyard MIS, is to provide the information needed to control and continually reconcile these two accounts. Ideally, this reconciliation should be a routine operation, however, due to processing delays, changes in prices, and partial deliveries, unliquidated or unreconciled balances have a tendency to accumulate in both accounts.

Both civilian commercial and Navy supply system transactions are controlled by this application using the Accounts Payable/Material-in-Transit Master File. When a receipt of material is processed, the transaction will establish a record in the accounts payable fields of the file and blanks in the material-in-transit fields. When a paid bill transaction is received, the transaction is entered into the file, the two sides are balanced, and the record liquidated. The file also contains detailed historical data on document numbers, federal stock number transactions, unit prices, partial deliveries, and delivery quantities. Fifteen reports are produced by the Accounts Payable Reconcilation Application, most of which are tools designed to aid in the liquidation of unreconciled balances in the two accounts.

3. Material Management Subsystem

The Material Management Subsystem is designed to provide continuous quantitative, financial, and status information on industrial materials. Industrial Materials are those materials, and services, purchased with shipyard operating capital provided through the Navy Industrial Fund. The Shipyard MIS Material Management Subsystem processes transactions for Direct Material Inventory (DMI), End Use, and Shop Stores. Outputs include reports of material commitments for outstanding orders, receipts and issues, inventories, catalogues, transaction exceptions, and a wide range of material status reports used to monitor and control the entire cycle of shipyard operations.

a. Types of Materials Managed

The productive work of a naval shipyard requires a wide range of materials and services which must be defined, ordered, controlled, stored, issued, and for some items, disposed of through excess channels. These materials are of three general types: shop stores, direct material inventories, and services. Shop stores are materials that are used on a regular recurring basis by the shipyard shops, these items are generally ordered in quantity for a particular shop and are stored at the shop in anticipation of normal consumption patterns. By far the largest investment in shipwork materials are direct material inventories; DMI items are ordered against a customer order and stored for a specific ship availability. The Planning Department is responsible for deciding which items should be ordered and stored as DMI - although they are not assigned a specific job order until the requirements for KEYOPS and job orders are established.

In addition to shop stores and direct material inventory information, the subsystem handles data and information for a variety of services. Types of services included are travel and transportation, transport of material, utilities, printing and reproduction, and other contractural services. The commitments for these services are treated like end use material and are identified by alphabetic codes to designate the particular service of concern. Shop stores and direct material inventory items may be obtained by purchase from local or national suppliers, from main Navy inventories, or from the Defense Supply Agency if the item requested is a standard stock item within one of those systems. All materials and services are requisitioned through the shipyard Supply Department and entred into the Shipyard MIS Material Subsystem as material control records and commitments of funds. Two applications form the heart of the Material Management Subsystem: the Industrial Material Application and the Shop Stores Application.

b. Industrial Material Application

This application of the Shipyard MIS records and controls the procurement, receipt, issue, and where necessary, disposal of shipyard direct material. The Industrial Material Application provides a bridge of information between order recording and actual material usage which spans status and inventory operations and leads to material support by job order and key operation references. A major goal of the application is to provide shipyard managers with essential information that is required in order to determine the quality of material support for production. Other goals include identification and status of critical items, determination of causes of excessive direct material inventories, determination of error sources, and the determination of the cost of residual materials.

The Industrial Management Application concerns itself with four different transaction areas: orders for goods and services (commitments), DMI, financial, and pre-pricing transactions. Commitment transactions establish new and liquidate old commitments and establish the various associated delivery dates. DMI transactions add, change, and delete Direct Material Inventory data including orders, requisitions, procurements, shipments, receipts, and transactions on excess material. Financial transactions address old dodlar data and errors related to the DMI transactions. Pre-pricing transactions provide for material charges against job orders before the material is received and the final price determined. The Validation Master File of the Cost Application is also employed in this application to determine whether a commitment has been made to a valid job order number.

Inputs to this application include commitment data in the form of job material lists, receipts and adjustment data, issues, material status, and file maintenance and control data. The application processes these inputs and provides five report families: exception reports, status reports, control reports and reference reports. Exception reports are used to report status data on all material classified locally as both critical and in jeopardy. Status reports provide comprehensive status information on all material items ordered, due, on hand, and issued. Control reports provide dollar data on DMI usage at shops and expense centers. Situation reports include items for which delivery is beyond the required delivery data. Reference reports contain cumulative history of all material transactions processed and functions as an aid in researching material discrepancies.

c. Shop Stores Application

The productive work of naval shipyards requires a wide range of materials which must be defined, ordered, controlled, stored, issued, and sometimes disposed of. Shop Stores are the consumable materials which must be used regularly by shipyard shops and are managed by the Shop Stores Application. This application processes all inventory transactions, projects material replenishments, prepares various shop stores catalogues, and generates a series of reports and output cards that aid in controlling stockage levels.

Three files are maintained by the Shop Stores Application: the Stock Item Record File, the Leger File, and the Description File. The Stock Item Record File stores transactions on opening and closing balances and records all receipts, issues, and expenditures against each shop stores item. The Ledger File maintains opening and closing dollar balances for each shop store, together with the accumulated values of receipts, issues, and adjustments. The Description File stores descriptive information on shop stores items that is used in the preparation of replenishment requisitions and material catalogues. In addition to maintaining these system files, the application automatically initiates replenishment actions whenever stock balances reach a predetermined reorder level.

Inputs to this application include material receipts for shop stores, material issues for shop stores, management established parameters on the type and quantity of output information, and data on item description such as prices, quantities of issue, and sources of the material. Twenty reports are distributed among the replenishment, stock status, catalogue, work measurement, and control report families. Replenishment reports project usage rates into recommended reorder levels and dates. Stock status reports provide total values of shop stores including total value statistics. Catalogue reports assist in the preparation of on-hand and available item listings. Work measurement reports provide a summary of inventories as well as statistical measures of shop stores activity. Control reports provide information on special actions that may be required to locate stock, correct errors, and transfer materials.

4. Administrative Subsystem

In addition to the eleven applications previously discussed within the three major Shipyard Management Information System Subsystems, there are five other applications which serve all other shipyard functions from a common data base. These miscellaneous applications are not directly classifiable into any specific subsystem since they are basically independent functions, but have been grouped together into the Administrative Subsystem for ease of identification and reference. They are: the Radiation Exposure Information Application, the Personnel Management Application, the Plant Accounting Application, the Public Works Application, and the Depot Maintenance Application.

a. Radiation Exposure Information Application

The Radiation Exposure Information Application of the Shipyard Management Information System, maintains records on the cumulative exposure of shipyard personnel to ionizing radiation associated with naval nuclear propulsion plants for those shipyards who maintain a nuclear capability. Report families produced by this application include individual exposure reports, job order reports, and radiation exposure reports required by higher authorities. A number of the reports generated by the application are required by the Bureau of Medicine and Surgery, Energy Research and Development Agency, and the Headquarters of the Naval Sea System Command. Nearly all of the remaining reports are used to ensure that individuals do not receive more ionizing radiation than prescribed by the Bureau of Medicine and Surgery.

The Radiation Exposure Information Application employs two files: the Radiation Control Personnel Master File and the Job Order Master File. The Radiation Control Personnel Master File contains all data transactions needed to report on personnel radiation exposure, including daily, weekly, monthly, quarterly, yearly, and life accumulations of radiation exposure dosages. Dates are also maintained in this file for scheduling radiation exposure training and the periodic medical examinations required for continuing qualification of individuals as nuclear workers. Transactions on radiation dosages are obtained from the Radiation Monitor and the Daily Dosimeter Reading Card which records time in and out of the radiation area, job order number, and dosimeter reading for each exposure, including zero readings. The Job Order History Master File contains job order, shop number, work category, job order title, and original and revised estimates of exposure to ionizing radiation, per worker.

b. Personnel Management Application

The Personnel Management Application of the Shipyard MIS maintains the personnel records of all civilian employees of the shipyard.

As part of this effort, the application provides current status information on individual employees, maintains files of pending personnel actions, and reports historical and reference information on a number of diverse classes of shipyard personnel statistics including turnover, average grade, position titles, awards, minority employees, reductions in force, welder qualifications, marital status and tenure. In addition, the application provides data inputs to the standardized Navy Automated Civilian Manpower Information System maintained by the Office of Civilian Manpower Management (OCMM); it serves the Training Requirements and Information Management System, also OCMM run; and it provides equal opportunity information and statistical analysis.

All shipyard personnel data are input to the Personnel Management Application by the Base Industrial Relations Office. A matching program is employed to edit the integrity of data that are common to both the Payroll and Personnel Management Applications. The application employs nine separate files; a Master Data File of personnel statistics, two History Files, a Position Title File, a Department Table of Organization File, an Awards File, a Minorities File, and a Welders Qualification Master File. More than fifty reports are generated by this application to describe personnel actions and activities. Reports listings are available on demand which can respond to almost any desired personnel statistical profile by selecting and listing data stored in the files. Major report areas are distribution of civilian personnel, average grade computations by department, equal opportunity summaries, and age profile reports.

c. Plant Accounting Application

The Plant Accounting Application provides the controls over Federal Government property that are essential to comply with the statutory requirements of the Secretary of Defense, and to fulfill the objective of insuring that information is available for management and technical purposes both on a physical, and a monetary, inventory of equipment basis. Information concerning Property Class 3 (other than industrial plant equipment) which includes all Navy-owned property with an acquisition cost of two-hundred dollars or more, and Property Class 4 (industrial plant equipment) with an acquisition cost of one-thousand dollars or more, is required.

Six basic input functions are provided to the Plant Accounting Application. They are: intial loading transactions which report the acquisition of material; identification number changes which update history files; changes to master files; monetary changes which reflect depreciation and cost factors; dispositions of outdated and surveyed equipment; and transfers of equipment to the custody of another shop within the shipyard or to an external activity. The Plant Property Clerk is responsible for the posting of the transactions which reflect the activities concerning plant accounting. Twenty output reports are divided into two report families. Plant account transactions reports include summaries of maintenance activities, a summary of acquisitions, equipment rejects and dispositions by class. Plant account file items report equipment items by nomenclature and Navy identification standard. Quarterly equipment master lists, plant equipment lists, as well as inventory summaries are also provided.

d. Public Works Application

The Public Works Application supports current Public Works Department reporting requirements. The objective of this application is to support facilities requirements in addition to reporting public works performance and financial accountability in support of the shipyard industrial effort. Five report families provide information on the transportation, controlled maintenance, family housing, maintenance cost analysis and base utilities areas.

The transportation report family provides a means for accounting for transactions processed for public works usage including operation and maintenance of vehicles. The controlled maintenance family uses the Shipyard Management Information System Daily Timecard as an input and produces weekly status information reflecting progress made by individual shops on Public Works Department work orders; these reports provide for completed work summaries and final costings including man-hour expenditures. Maintenance cost analysis reports are prepared from data extracted from the Financial and Operations File and reflect fiscal year cost data related to real property maintenance functions.

Family housing reports provide maintenance status and occupancy rate information on military family housing within the shipyard Public Works Department's purview. This data is also extracted from the Financial and Operations File and is concerned with categories such as flag, officer, and enlisted occupancy statistics as well as an overall cumulative housing report. Utility reports are prepared on a monthly, quarterly, and yearly basis and are concerned with power plant operations for those shipyards with their own power generating facility.

e. Depot Maintenance Application

The Depot Maintenance Application provides for the accumulation, recording, and reporting of comparable information on the operations and accomplihsments of depot maintenance activities related to weapons systems supported and items provided. Beyond this, the application enables shipyard management to measure productivity, develop performance and cost standards, and determine where management emphasis should be directed. The application provides the capability to periodically review depot maintenance accomplishments in relation to: planned programs, the use of facilities provided for the support of weapons systems, depot maintenance cost in comparisons with the alternative of replacement cost of a specific item, and comparative costs among depot maintenance activities or between depot activities and civilian contract sources for the same type of work. Also, the application provides a catalogue of maintenance capability, shows where duplication of industrial capacity exists, and indicates both actual and potential areas for interservice maintenance support.

Five digit Customer Order Acceptance Record, and ten digit job order numbers, accounting data, availability types and expenditures are extracted from the Cost Master File. Other required information is entered directly to the application by card input. Inputs consist of required file maintenance items provided for any data element on the Depot Master File including values of exchanged material, standardized inventory processes, and all codes for work categories of all non-shipwork areas.

The Master File Extract and Depot Maintenance File summarizes labor hours, labor overhead amounts, direct reimbursement costs, and material totals. It thus creates an updated Depot Maintenance Master File and produces output card decks which are used as inputs to the next activity, and creates a listing of all of the extracted data. The Depot Maintenance Hold File creates depot maintenance data for customer orders that have not yet been extracted from the Cost Master File. The Depot Master File is edited quarterly to insure completeness and validity of data.

The Depot Maintenance Application provides ten output reports divided into two output families. Periodicity of a specific report may vary from monthly to annually depending on the requirements of the external agency or shipyard department to which the report is sent. Reports are produced which provide for the functions of audit control and information for internal management and higher authority reporting requirements. These provide summary information relative to the operations and accomplishments of depot maintenance activities. Additional reports concerning the measurement of productivity, performance and cost standards, utilization of facilities, and depot maintenance costs as opposed to potential replacement costs are also provided. Since many shipyards do not provide weapons maintenance facilities, this application is not implemented in all Shipyard Management Information System activities.

E. CONTROLS OVER THE SHIPYARD MIS

The Headquarters of the Naval Sea System Command retains the responsibility for establishing the overall policy for shipyard management and

and the Shipyard Management Information System. The NAVSEA office assigned the overall responsibility for the Shipyard MIS is NAVSEA 07, the Industrial and Facility Management Directorate. Control over changes and alterations for the Shipyard MIS is the responsibility of the Management Information System Executive Group (MISEG). This top-level advisory group is composed of three senior Shipyard Commanders who establish policies concerned with the Shipyard MIS and review all proposed system changes.

The responsibility for the centralized design and implementation of the Shipyard MIS is vested in the Computer Applications Support and Development Office (CASDO). CASDO is an office of NAVSEA 07 whose overall direction is provided by the MIS Executive Group, and is located in Boston, Massachusetts. CASDO does not initiate changes but provides central guidance, control, and coordination as it encourages the users of the system to suggest improvements. CASDO responsibilities include: identification and definition of shipyard information and data systems requirements; system development; processes of integration with other information systems; technical direction on the development of required computer programs, including continuing maintenance; providing assistance in the implementation of the standardized MIS where necessary, including training of personnel in its use; control of the standards and procedures pertaining to the design, development, and implementation of the MIS, and any other shipyard computer based management system, as necessary.

CASDO consists of a relatively small group of people whose backgrounds are in shipyard operations and computer systems. CASDO is not a programming office. Should programming for the Shipyard MIS be required, CASDO writes a rigid set of specifications for the work to be done and sends it to one of the shipyards. Each shipyard specializes in one particular portion of the MIS. After the new program is written, corrected, and checked for accuracy, it is incorporated into the standard MIS package and distributed to all of the shipyards. Each shipyard originally employed nine to twelve programmers for such maintenance activities.

1. System Improvements

In general, the major thrust toward systems changes reside with the system's users as encouraged by CASDO. Shipyard personnel continually review the effectiveness of the MIS as it meets their needs, identify problem areas which reflect trouble or lack of information on the part of the user, and, in turn, report the problems to CASDO who reviews and passes them on to MISEG for resolution. MISEG further reviews the problem to assess its applicability to all shipyards, to ensure the proposed resolution will be consistent with NAVSEA policy, and to determine the technical and economic feasibilities of a system-wide resolution. CASDO and shipyard resources are employed for analysis, programming, and validation, as described above, prior to the issuance of any coordinated solution proposed for inclusion in the standard computer library of operations.

2. Changes to System Outputs

Because of the dynamic nature of shipyard management and information required for its support, the Shipyard Management Information System design provides for changes to the outputs, some of which may be made almost immediately at the request of the user. Depending on the type of change requested, a review for approval process is initiated as outlined below:

Change	Changer	Accomplished By
Add new reports; drop old reports; correct reports	User	Letter to MISEG indicating what changes are desired and why
	CASDO	Review of request; letter to MISEG
Error or deficiency within system other than with reports	MISEG	Approval to CASDO for change; Advises CASDO giving particulars
	CASDO	Initiates corrective action
Suggested improvement (a "good" idea)	User	Proposal letter to CASDO outlining justifications and cost savings
	CASDO	Analyze and forward
	MISEG	Approval to CASDO for change
Change report parameters	User	Local request to data processing office
Change file data; correct errors	User	Local request to DP office; file update
Change request sequence	User	Local request to DP office
Change report frequency	Computer Operator	Introduces appropriate transaction code to computer

F. FUTURE OF THE SHIPYARD MIS

From its inception, the Shipyard MIS was envisioned to have three evolutionary stages: The first stage allowed individual shipyards a high degree of autonomy and resulted in diverse systems and equipment; the second stage called for the evolution of these systems and equipment into an aggregate of compatible, multipurpose subsystems, designed so that a high degree of uniform system products would be available to each shipyard. This stage required centrally controlled development of major subsystems and applications. The third stage is one of refining the subsystems, largely through improvements and standardization of the system's programs, plus an expansion of system coverage. The Shipyard MIS is fully involved in this stage.

Part of the plans for the future call for expansion of the Shipyard MIS through the design of new applications and the improvement of existing ones. One area that is being designed for addition to the existing system is a Quality Assurance (QA) program. The QA function is already a large data-handling burden for shipyard operating personnel. Another application area requiring complete implementation is tool control. Shipyards have a large investment in hand tools. Since the full incorporation of nuclear work in some shipyards, the criticality of some tools has increased and it is now necessary to provide for a completely automated tool inventory and control system. An area of great importance that will improve an already existing application by furnishing status reports on material movement within the shipyard are reports that will help to alleviate a major shipyard frustration: trying to locate material known to have been received, but which is presently at some point between the receiving dock in the Supply Department, and the ship requiring the material. Development of a material progress system using on-line communication techniques should not only eliminate this frustration, but also save many productive man-hours needlessly expended in the search for the material.

As can be surmised, future Shipyard Management Information System objectives will involve a considerable expansion and reorientation of the existing Shipyard MIS. Much of this expansion will consist of adding new applications to, or improving on existing subsystems. Because some of the proposed new applications may not logically relate to any of the existing subsystems, it may be necessary to develop new subsystems to accommodate them. Careful coordination of the various shipyard data processing centers, CASDO, and the MIS Engineering Group is required in this effort.

III. THE SHIPYARD MANAGEMENT INFORMATION SYSTEM AT MARE ISLAND NAVAL SHIPYARD

A. INTRODUCTION

Mare Island Naval Shipyard is located in Vallejo, California, at the northeastern corner of San Pablo Bay at the mouth of the Napa River. Seaward access to Mare Island is obtained through San Francisco Bay. From an intial land purchase by the Navy of 965 acres in 1853, Mare Island has grown through land reclamation and grants to its present size of more than 2,600 acres of hard land and almost 1,900 acres of tide-lands [15].

Mare Island Naval Shipyard (MINSY) is one of eight members of the Naval Shipyard Complex performing a wide variety of functions in support of the United States Navy. The other member yards are located in Portsmouth, New Hampshire; Philadelphia, Pennsylvania; Norfolk, Virginia; Charleston, South Carolina; Long Beach, California; Bremerton, Washington; and Pearl Harbor, Hawaii. The official mission of MINSY, and all the other naval shipyards as established by the Secretary of the Navy in SECNAVNOTE 5450 of 21 April 1956 is:

> To provide logistic support for assigned ships and service craft; to perform authorized work in connection with construction, conversion, overhaul, repair, alteration, drydocking and outfitting of ships and craft, as assigned; to perform manufacturing, research, development, and test work, as assigned; and to provide services and material to other activities and units, as directed by competent authority.

Although each naval shipyard is capable of performing a variety of services in the accomplishment of this mission, the Commander, Naval Sea

Systems Command, has designated special assignments for each of the shipyards. Mare Island Naval Shipyard's special mission involves the construction, conversion, and overhaul of all types of submarines and the overhaul of surface ships, including nuclear, except aircraft carriers [16]. The ship construction mission has since been deleted for all naval shipyards; however, portions of this capability still remain at Mare Island. The reactivation of MINSY's submarine construction capability would require considerable retooling and the acquisition and training of specialized craftsmen to obtain the balance of skills that are different from the present needs during overhauls. In order to adequately reestablish a construction capability from the present personnel standpoint has been estimated to require at least two years.

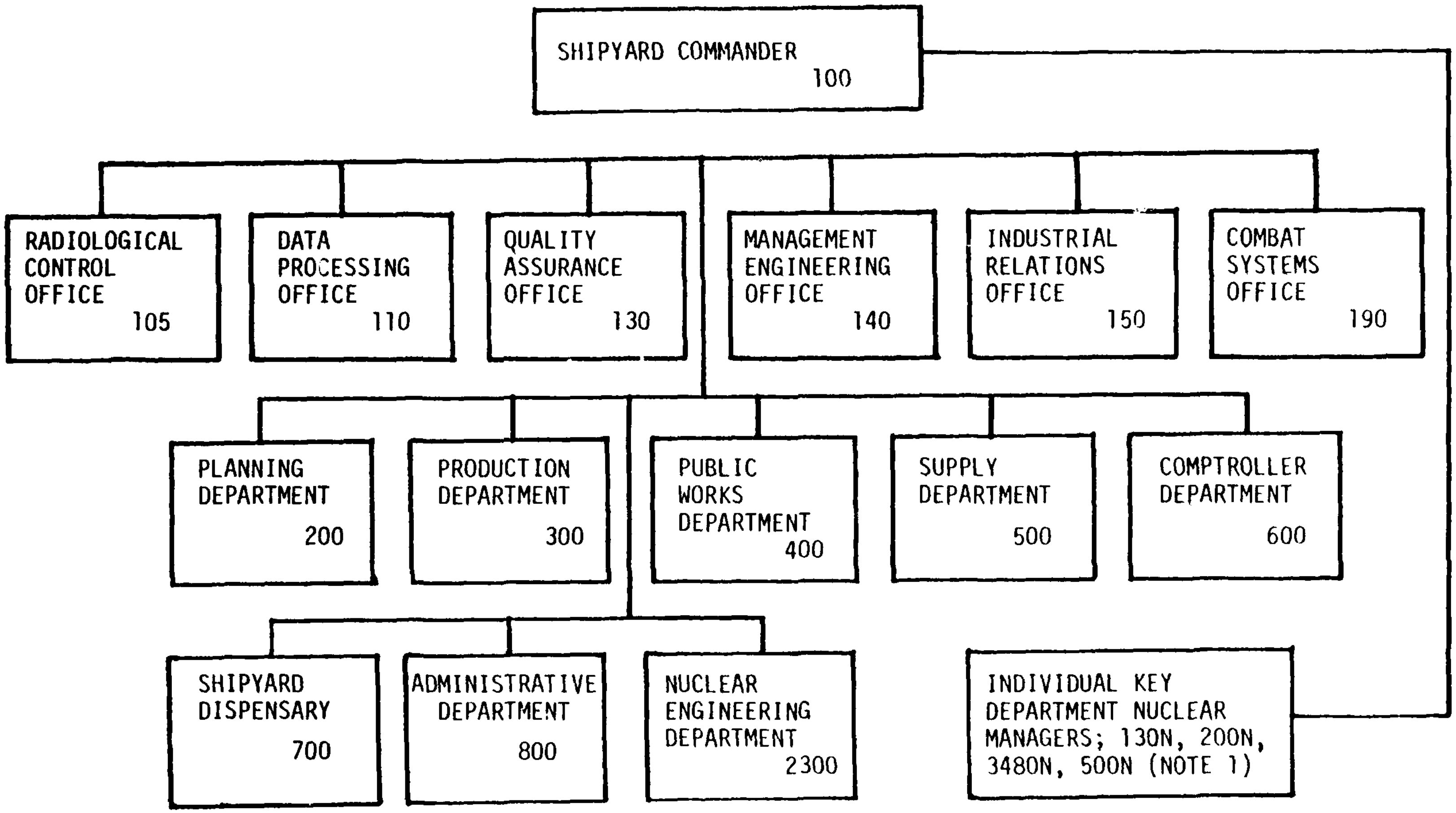
B. ORGANIZATION

1. MINSY Overall Organization

Figure 6 depicts the organization of Mare Island Naval Shipyard as it releates to the data processing function, and shows the overall relationship of the major offices and departments of the shipyard to each other [17]. Primary responsibility for the operation of the shipyard is vested in the Shipyard Commander (Code 100) who reports directly to NAVSEA 07 (Industrial and Facility Management Directorate) on matters pertaining to the operation of Mare Island Naval Shipyard. The nuclear management structure of the shipyard is included for purposes of continuity. Within each organizational block, the shipyard functional code is provided since shipyard offices are often referred to by code instead of title.

Figure 6

SHIPYARD ORGANIZATION CHART



NOTE 1: Direct Assess to Shipyard Commander on Nuclear Matters

2. Organization of the Data Processing Office

Figure 7 depicts the organization of the Data Processing Office (Code 110) as it is further subdivided into an Analysis and Programming and an Operations Division. The Analysis and Programming Division is responsible for directing and coordinating the performance on non-engineering automatic data processing systems design and analysis studies for all organizational components. This division is further partitioned into speciality areas with specific programmers assigned to specific sections of the Shipyard Management Information System as their particular area of expertise. These specialty areas are concerned with financial and material applications, and special projects. Industrial and advanced programming applications, although part of the MINSY data processing effort, have a dual responsibility to the Computer Applications Support and Development Office (CASDO) and NAVSEA 073 (Industrial Activity Management Systems Division) for maintenance of the Industrial Subsystem portion of the Shipyard MIS for the Naval Shipyard Complex.

The Operations Division is responsible for the planning, scheduling, and directing of the operation of the data processing computer and its peripheral equipment within the Data Processing Center. The division maintains liaison with all shipyard departments in order to develop a schedule for the accomplishment of data processing activities in accordance with established priorities. It also provides assistance to the Analysis and Programming Division in programming and debugging, when requested, and reports difficulties in using data and programs supplied to the departments and divisions concerned. The scheduling branch performs report scheduling and distribution functions. Actual

AD-A085 031 NAVAL POSTGRADUATE SCHOOL MONTEREY CA F/G 9/2
DISTRIBUTED DATA PROCESSING IN A UNITED STATES NAVAL SHIPYARD.(U)
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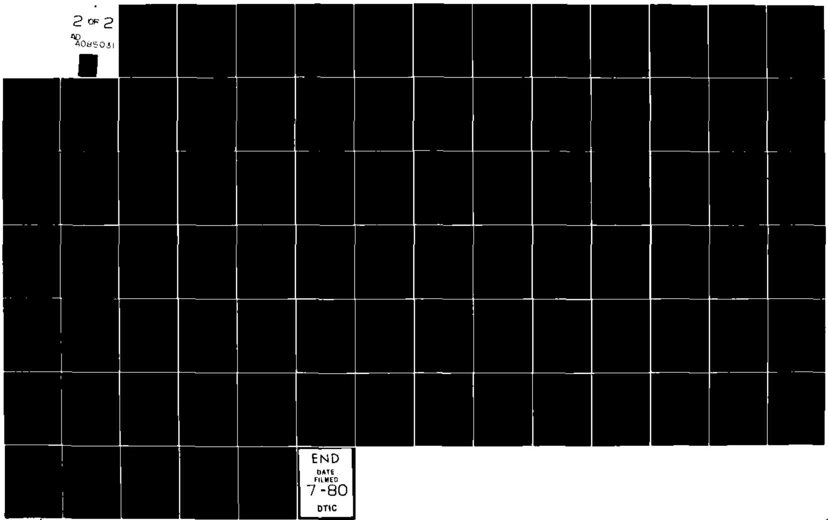
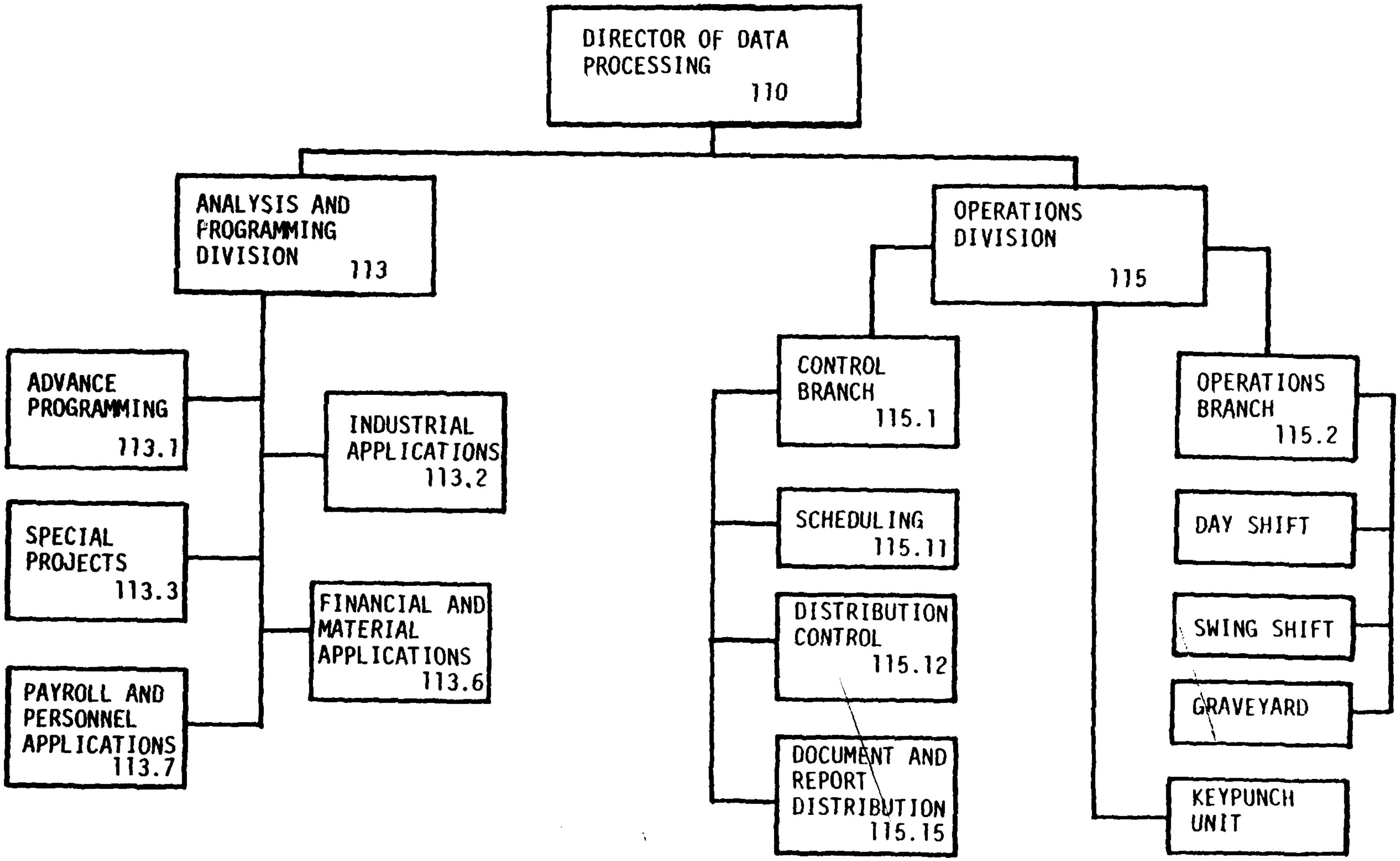


Figure 7 DATA PROCESSING OFFICE ORGANIZATION



equipment operations are accomplished by the operations branch on a continuous twenty-four-hours-a-day, seven-days-a-week shiftwork basis. Keypunch facilities and personnel are also under the control of the Operations Division. Figure 8 provides a breakdown of personnel manning within the Data Processing Office by position, paygrade (G. S.), number of personnel at that level, and annual salary range as of October, 1979.

C. DATA PROCESSING GOALS REALIZED

The primary objective of Mare Island's data processing facility, as summarized by the head of the Operations Division of the Data Processing Office, is to: " . . . be responsive to customer requirements. This facility provides a service to the user, and exists so that he has available the best information upon which to base his decisions." Thus, the overall objective of the Shipyard Management Information System, as implemented at MINSY, is to provide accurate and timely information in an easily understandable form that is practical, useful, and meaningful to shipyard decision-making efforts. Additional goals of a less generalized nature include: cost control, economy, forecasting, planning, flexibility, and provisions for expansion.

The MIS aids cost control by bringing together in an integrated data base the costs of labor, material, and operations which achieve increased operating efficiency through better work scheduling and more effective use of personnel, equipment and inventories. Shipyard MIS functions are also integrated to provide economy of operations in that similar operations are combined; data processed in one functional area is transmitted within the system to other applications which require the same information

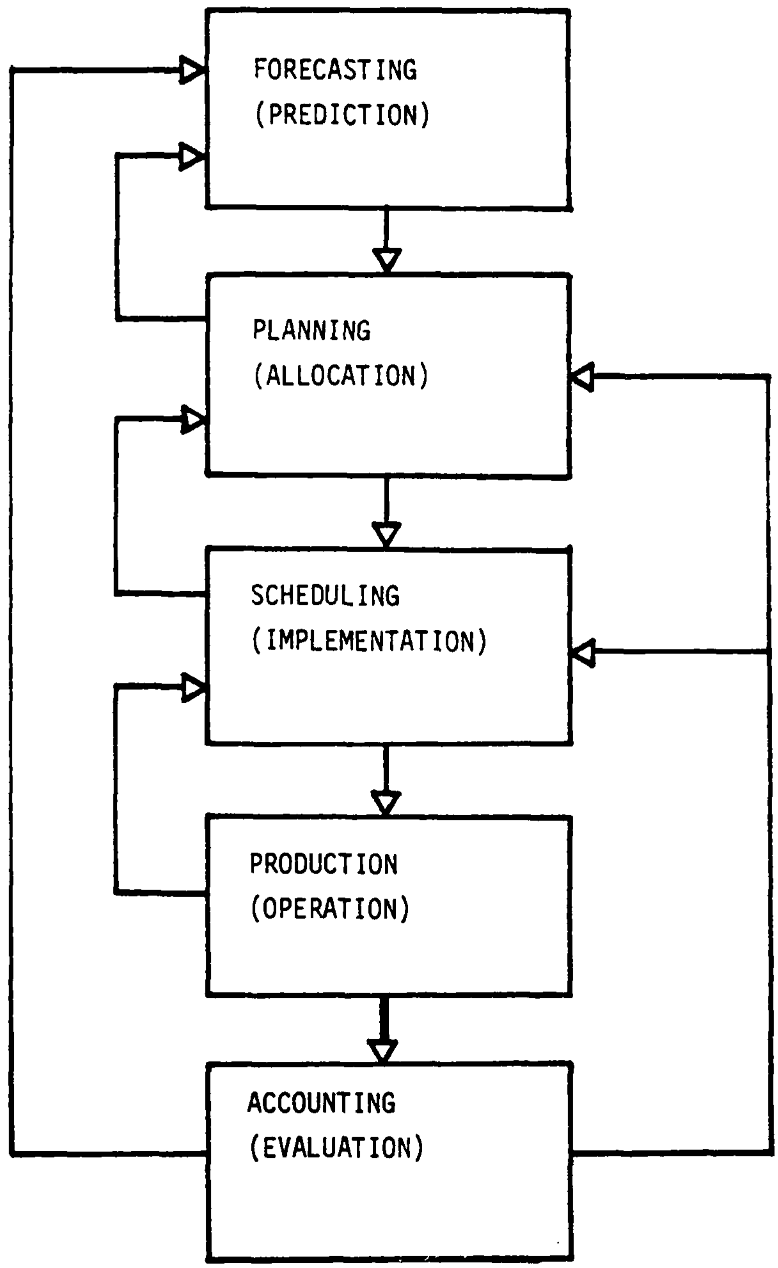
Figure 8 DATA PROCESSING OFFICE MANNING

POSITION	G.S.	NUMBER	SALARY RANGE (IN DOLLARS)
DIRECTOR OF DATA PROCESSING			
DIRECTOR	14	1	34,713 - 45,126
SECRETARY	6	1	12,531 - 16,293
ANALYSIS AND PROGRAMMING DIVISION			
HEAD	13	1	29,375 - 32,110
COMPUTER SPECIALIST	12	6	24,703 - 38,186
COMPUTER SPECIALIST	11	12	20,611 - 26,794
COMPUTER SPECIALIST	9	3	17,035 - 22,147
OPERATIONS DIVISION			
HEAD	12	1	24,703 - 38,186
CLERK	4	1	
CONTROL BRANCH			
HEAD	10	1	18,760 - 24,385
COMPUTER TECHNICIAN	9	2	17-035 - 22,147
WAREHOUSEMAN	6	1	12,531 - 16,293
COMPUTER AID	5	2	11,243 - 14,618
COMPUTER AID	4	1	10,049 - 13,064
LABORER	2	1	8,128 - 10,327
DAY SHIFT			
SUPERVISOR	9	1	17,035 - 22,147
COMPUTER OPERATOR	7	4	13,925 - 18,101
KEYPUNCH SUPERVISOR	6	1	12,531 - 16,293
KEYPUNCH LEADER	5	1	11,243 - 14,618
DATA TRANSCRIBER	4	9	10,049 - 13,064
DATA TRANSCRIBER	3	3	8,592 - 11,634
COMPUTER AID	5	1	11,243 - 14,618
SWING SHIFT			
SUPERVISOR	10	1	18,760 - 24,385
COMPUTER OPERATOR	7	4	13,925 - 18,101
KEYPUNCH SUPERVISOR	6	1	12,531 - 16,293
KEYPUNCH LEADER	5	2	11,243 - 14,618
DATA TRANSCRIBER	4	10	10,049 - 13,064
DATA TRANSCRIBER	3	1	8,592 - 11,634
GRAVEYARD			
SUPERVISOR	9	1	17,035 - 22,147
COMPUTER OPERATOR	7	3	13,925 - 18,101
COMPUTER OPERATOR	5	1	11,243 - 14,618

which, in turn, avoids duplication of effort and reduces clerical tasks. Formalized Shipyard Management Information Systems methods of predicting expected future performance based on actual past performance are available to fulfill the forecasting objective. The uncertainty of the future is minimized using the planning functions of the MIS in that data can be obtained, translated, understood and communicated to improve the rationale of current decisions that are based on future predictions. The Shipyard MIS is flexible in that it readily accepts changes such as new data files, new procedures, and new output functions. The modular design of the MIS allows for system expansion and response to evolving managerial requests and provides for advances in system products and additional services for system users.

The primary functional area of support is the monitoring of the entire work process from planning of the work package to the certification of completion by the cognizant shipyard department head. This involves balancing the status of the work effort in relationship to the predetermined plans and schedules. Situations that are outside the established criteria for acceptable performance, based primarily on time and/or cost factors, are then to be highlighted as jeopardy situations so that managerial attention may be applied. Monitoring and control, although not generally considered to be synonomous terms, are used interchangeably at Mare Island; they refer to the implementation of plans and the use of feedback, as demonstrated by figure 9, so that shipyard objectives are optimally attained. The feedback loop is the central concept of control/monitoring, and timely, systematic appraisals of operations as provided by the Shipyard Management Information System and is the chief

Figure 9 MIS SYSTEM FEEDBACK



means of providing useful feedback to enhance shipyard operations.

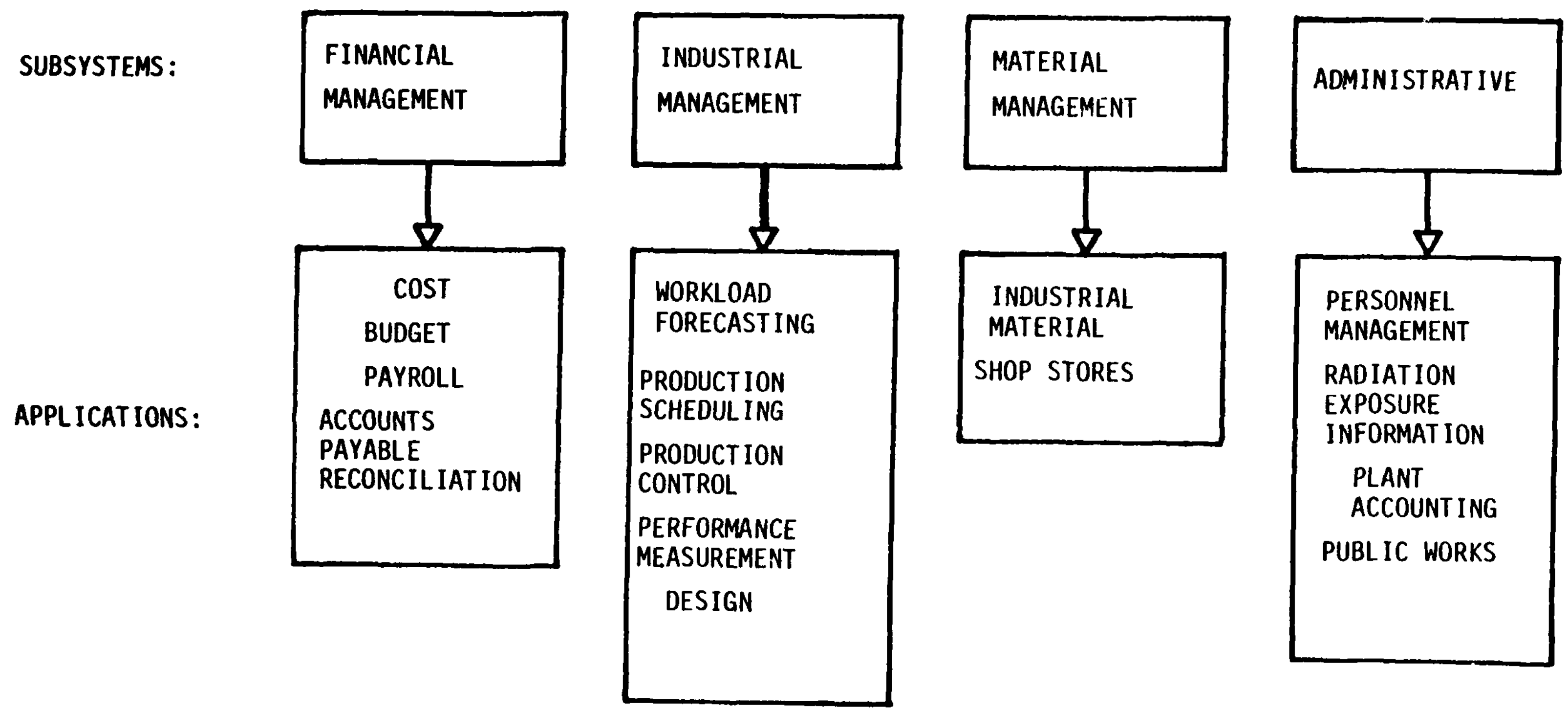
D. SYSTEMS AND APPLICATIONS OF MINSY's SHIPYARD MIS

The Shipyard Management Information System at Mare Island Naval Shipyard is composed of four subsystems with a total of fifteen applications. It is an integrated system with many interfaces between applications. A data element is introduced only once and may then be used by many applications. Figure 10 illustrates the four subsystems and how they are broken down into their component functional application areas. Although each application was discussed in depth in Chapter II and is completely specified by reference 14, a brief description of each application as employed at MINSY follows:

The Cost Application is by far the largest single application of the Shipyard MIS. It accomplishes four major tasks for shipyard management. First, it provides the cost information needed to monitor orders received from customers for work to be accomplished; second, it provides the overhead information needed for overall financial management of the shipyard; third, it collects the data required to generate the shipyard's Financial and Operating Statements; and finally, it provides the means and resources to answer requests for additional cost data from the Department of Defense, the Naval Sea Systems Command, and other Navy commands.

The Budget Application assists in the development of the information required for the generation of the shipyard overhead budget. The purpose of the Payroll Application is to accomplish the timely and accurate payment of all shipyard civilian employees and to generate all of the related reports required by the shipyard and various governmental agencies. The Accounts Payable Reconciliation Application provides the information

Figure 10 SHIPYARD MIS SUBSYSTEMS AND APPLICATIONS



needed to control and continually reconcile the accounts payable account.

The Workload Forecasting Application provides a forecast of the overall shipyard workload for direct labor personnel, a comparison of man-days authorized to be expended by scheduled time-frame against available force, and an account of the expenditures of total man-days in comparison to the authorized and scheduled work. The Production Scheduling Application supports the establishment and control of work schedules. The Production Control Application provides information on the status of work in the shipyard. The Performance Measurement Application measures variances between planned work and actual performance. The Design Application provides the tools for managing the engineering drawing and specification development effort of the shipyard.

Shipyard material is divided into two types: direct material and shop stores. Direct material is that material that is ordered with a specific end use on customer funded work identified. Shop stores are the consumable and high usage/low unit value material items that are used regularly by shipyard shops. The Industrial Material and Shop Stores Applications support the management of two types of material. There is considerable interface between the two applications such that the using shops can be provided with a report identifying the status of all of the material required for a job regardless of its source.

The Personnel Management Application, in conjunction with the standardized Navy Automated Civilian Manpower Information System (NACMIS), maintains personnel records of all civilian employees of the shipyard. The Radiation Exposure Information Application maintains records on the cumulated exposure of shipyard personnel to ionizing radiation associated

associated with naval nuclear propulsion plants. The Plant Accounting Application supports the inventory, acquisition, deletion and depreciation of shipyard property and equipment. The Public Works Application provides information on operation and maintenance of transportation, utilities, family housing, buildings, and other facilities and equipment.

E. DATA PROCESSING INPUTS

Input to the data processing system comes from many sources. Data may physically enter the system on the standard eighty-column punch card, the design of which is controlled by various transaction codes (TCs). Information is also input directly into an application program by other application programs within the Shipyard Management Information System. Inputs to the Ship Work Control System, to be more thoroughly discussed later, are accomplished through terminal processing controlled by Transaction Processing Applications Programs.

1. Transaction Codes and Designators

A transaction is a set of input data which initiates a consistent operation or sequence of operations in a given computer program. Each transaction contains a code for identification. This transaction code is the means by which a program recognizes, classifies, and processes the data. The Shipyard MIS uses more than fifty-thousand different transaction codes to allow for effective, economical processing of the millions of elements of data which must be stored in the Shipyard MIS computer files. The code itself is made up of three alpha-numeric characters preceeding the transaction data. The first character identifies the application, the second and third characters identify the action required for the computer programs and prescribe the sequence in which the transaction will be processed.

Efficiency and economy of Shipyard MIS operations often necessitates construction of a computer program such that it offers various computational alternatives or options to the user, or allows him to enter data into the program itself. These computational alternatives are obtained by entering recognizable codes into the program; these codes are termed designators. In addition to providing management and operating personnel a tool to control the system options, designators are also used to insert certain constants that may be desired as part of an internal computation. They are also used to insert common elements of data that may be used by programs such as "today's date".

All inputs are in a fixed format as per input transaction code instructions found within each transaction code procedure. There have been attempts within the Operations Division of the Data Processing Office at MINSY to invoke free-formatting procedures, but they have met with resistance from local programmers and the CASDO office and thus are not likely to be implemented in the near future. Since there are thousands of input transactions within the family of structured inputs intended for the Shipyard MIS usage, it would be difficult to discuss all of them. Thus, the thirty-two transaction codes and designators which influence the operation of the Workload Forecasting Application of the Industrial Subsystem are summarized in figure 11.

2. Keypunch Procedures

Each transaction, if it is not presented to the data processing center on an eighty-column punched card, must be converted from the source document to the specific format required by the appropriate transaction

Figure 11 INPUT SUMMARY

General Heading	Type	Number	Name
Job Order Data	TC	566	Establish Job Order
	TC	570	Amend Job Order
	TC	574	KEYOP File Maintenance
Time Card Data	TC	055	Daily Clock Card
Performance Factors	TC	160	Shop Performance Factors
Forecasts	TC	273/4/7	Manning Curve
	TC	260/1	Ship/Project Manning Curve
	TC	262/3/6	Ship/Project External Loading
	TC	264/5/7	Ship/Project Fixed Loading
	TC	270	PWER Loading by Line Number
	TC	272	PWER Workload Estimates
Cancellations	TC	268	Ship/Project Cancellations
Estimates	TC	160	Percent of Workload Estimate by Shop
Shop/Code Rolls	TC	271	Shop Roll Adjustments
	TC	0003	Availability, Hull Index Number
	TC	269	Absent
	Design Card	0002	Branch Code Statistics
	Parameter Card	0001/4/5	Parameter Months, Time Span Report Heading
Reporting Options	Designator	PF20259	Work Category Selection
	Designator	PF40260 through 40276	Customer Order Selection
	Designator	PF20254	Report Request

code that will enable the data to be inputed to the Shipyard MIS. MINSY has established a library of 575 keypunch procedures that assist keypunch operations in the conversion of data from the source documents into the format/layout required for computer input. These instructions contain the following information:

Document Code
Originator Code
Process Code
Source Document Indicator with Instruction, if applicable
Field Number Indicator
Field Length
Field Descriptor
Card Column Instructions:
  X/B/Ø: X = must be keyed
         X/B = key if shown
         X/Ø = fill with zeros
Designator:
  Z/N/Z: A = alphabetic data
         N = numeric data
         Z = right justify and zero fill
         A/N = alphabetic and/or numeric data
S/D = a skip or a duplicate field indicator

Verification requirements are annotated by the letter "V" in the verification field. Each procedure also contains notes as to the disposition of missing or incorrect data fields found as a result of verification procedures. Instructions for the disposition of source documents are also provided.

Source documents are identified as to the proper keypunching procedure required by the shop supervisor prior to data submission to the DP center. Hand-coded entries on punch cards are resubmitted by the keypunch operator. Source documents that are not restricted to being inputed for processing by cards are submitted by batch number to the CMC (Computer Machinery Company) key entry system which houses the formatted data on a disc until it is transferred to the appropriate application file within the Shipyard MIS. Using this method, a journal file of raw data that is an image of keypunch transactions is kept as a backup and audit trail until such time as the transactions have been completely absorbed into the system (usually one week).

F. DATA PROCESSING PROCEDURES

There are more than four-hundred different reports that may be generated by the Data Processing Office at Mare Island Naval Shipyard. Each of these reports has its own unique processing requirements. It, therefore, is difficult to attempt a description as to how each of these reports is generated from raw data inputs, provide a listing of applications programs utilized, describe each file routing and detail the sorting routines employed. The orientation of this section, then, is to generally describe data processing procedures of the Shipyard Management Information System at Mare Island Naval Shipyard using the Daily Force Distribution Report (PF-102A), which is generated from the Workload Forecasting Application of the Industrial Management Subsystem, as an example.

1. Application Programs

Each application program resident within the Shipyard MIS is kept in its own binder within the data processing center of MINSY. Information contained for each of these programs include: a process chart of block diagrams illustrating the discs and/or tapes utilized; procedures for data extraction; a narrative description of any validation requirements, the read file, sorting comparisons utilized, and tape-write procedures that may be needed; the sort sequence is given; a description of input descriptions that may be required and disposition instructions for raw data; program disposition; periodicity and routing of output; description of constants, variables and control fields; a record of program changes; halts permitted; interrupt and restart procedures; associated data elements; and program listings as well as initializing test data are all provided. Two programs which provide the majority of the processing required to generate PF-102A are the Extract and Sort Program (PF-101) and the Edit and Update Force Data Program (PF-102). These two programs are further described below.

a. Program PF-101

The Extract and Sort Program, PF-101, is a Shipyard MIS application of the Honeywell provided Sort/Merge Program Family. This family of programs is able to accept a wide variety of data and task descriptions and dynamically adjust itself to the individual task required of it in order to provide for efficient processing. The Sort Function also features dynamic adjustment to the operating environment so as to maximize resource utilization especially during multiprogramming operations. Varying input and output files are utilized depending on the specific sorting program to be employed by the requesting process.

The Sort/Merge Family is engaged through a parametric descriptor program contained via the General Macro Assembly Program (GMAP). The parameters for sorting/merging are contained in macro control cards. Execution of the object program generated by these cards calls the Sort/Merge (S/M) Program from the Software System Library File. The parameters are interpreted and the desired program function engaged at execution time. Normal operations require few descriptive parameters since standardized functions and file descriptors are employed. Complex applications including merging of variable with fixed record lengths or partitioned records or any combination thereof, can be accommodated by S/M. Flexibility is gained through the employment of optional parameters in the required macro control cards or by the inclusion of optional macro control cards.

b. Program PF-102

This program edits the Daily Force and Schedule Load Files producing an output runoff (tape) which contains the two force reports in print format, reports PF-102A and PF-102B. These force distribution reports pertain mainly to man-hour expenditures on a day-by-day basis. The Daily Force (Input) File contains sorted force records used to process both reports. The Schedule Load File contains sorted load (authorized work force) and workload forecast records as inputs to the process. The Weekly Summary Input File contains the merged overhead force records from the start of the current processing week to the current data date, less one. At the start of the week, a sentinal tape replaces this tape since it has opened on the first day of the week.

The Print Tape File contains the two output reports as a result of the processing, in print format. The Weekly Summary Output File contains the merged overhead force records from the start of the processing week to the current data date. After completion of the last force run of the week, this tpe becomes the input to Program PF-200, Force Distribution. Sequencing of records within the program is by report key and by major to minor sequencing by transaction codes. Man-hour inputs are converted to man-days and rounded off to whole days for reporting purposes. The program has no check points, and is scheduled to halt only at the end of the job. If processing should stop for some reason, the program must be rerun in its entirety. The program requires four minutes of execution time and utilizes 57,675 positions of core space.

2. PF-102A Generation

Figure 12, with a continuation to figure 13, is the block diagram which illustrates the generation of the Daily Force Distribution Summary Report, PF-102A, and its sister report, the Daily Force Distribution Ship by Shop Report, PF-102B. Input is from three major areas: expenditures, load data, and forecast data. Expenditures information comes from time cards through the Financial Subsystem and into the Production Control Application Program PC-100 and then into Program PF-101. Load data originates with job order briefs and also passes through the Financial Subsystem and PROFILE into PF-101. Forecast data originates with transaction code input to Program PF-201 from which the data are then transferred to PF-101. PF-101 extracts and sorts information in preparation for relaying it to Program PF-102 for editing and force updating purposes prior to producing the reports in print format.

G. DATA PROCESSING OUTPUTS

The primary thrust of the data processing facility at Mare Island Naval Shipyard is the production of reports that are responsive to directives from higher authority as well as serving the needs of the local user. There are more than four-hundred possible reports available from the MINSY Shipyard Management Information System. As described in Chapter II of this presentation, each functional application contains one, or more, data files which contributed information to one, or more, report

Figure 12

PF-102A GENERATION

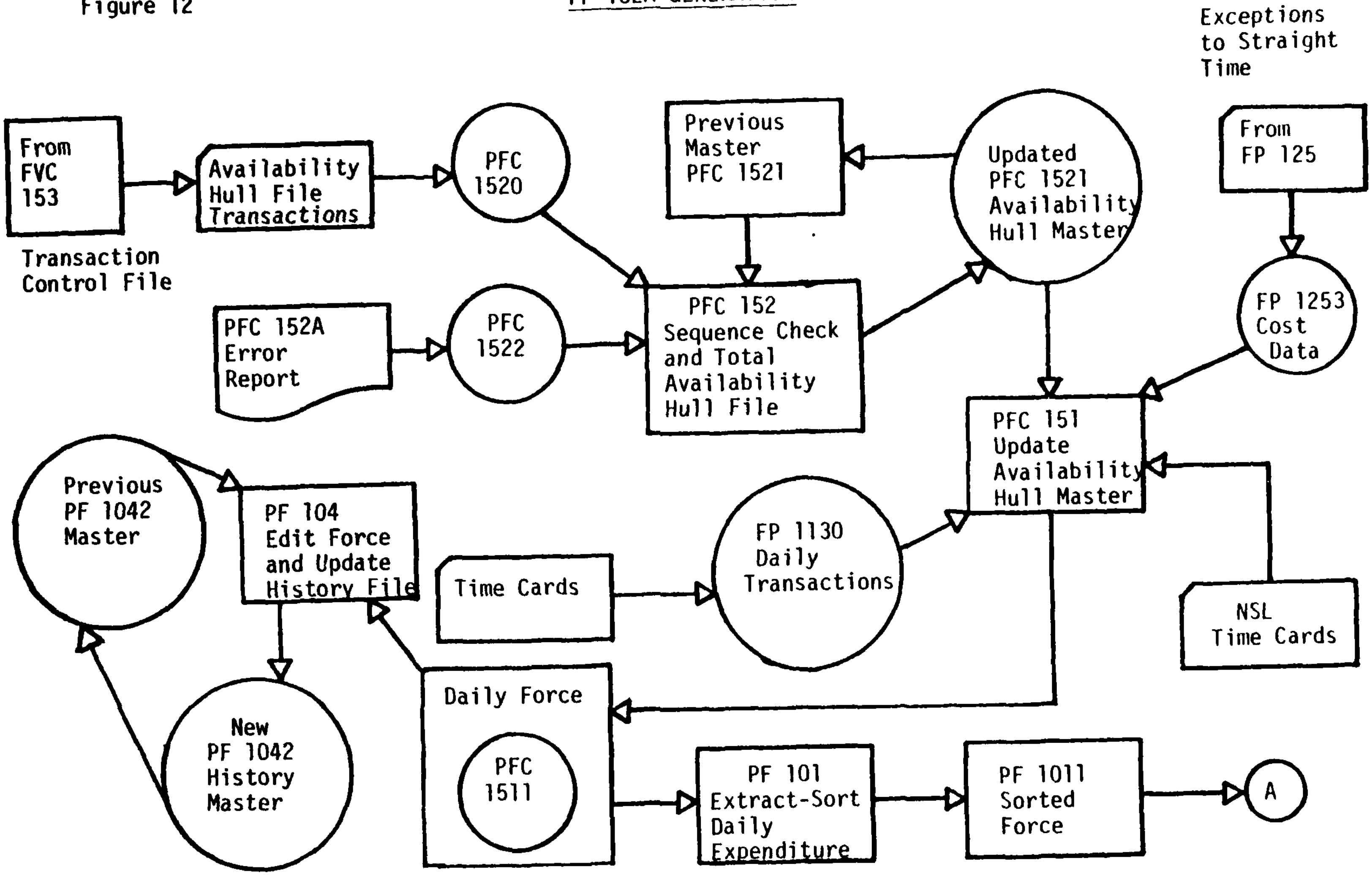
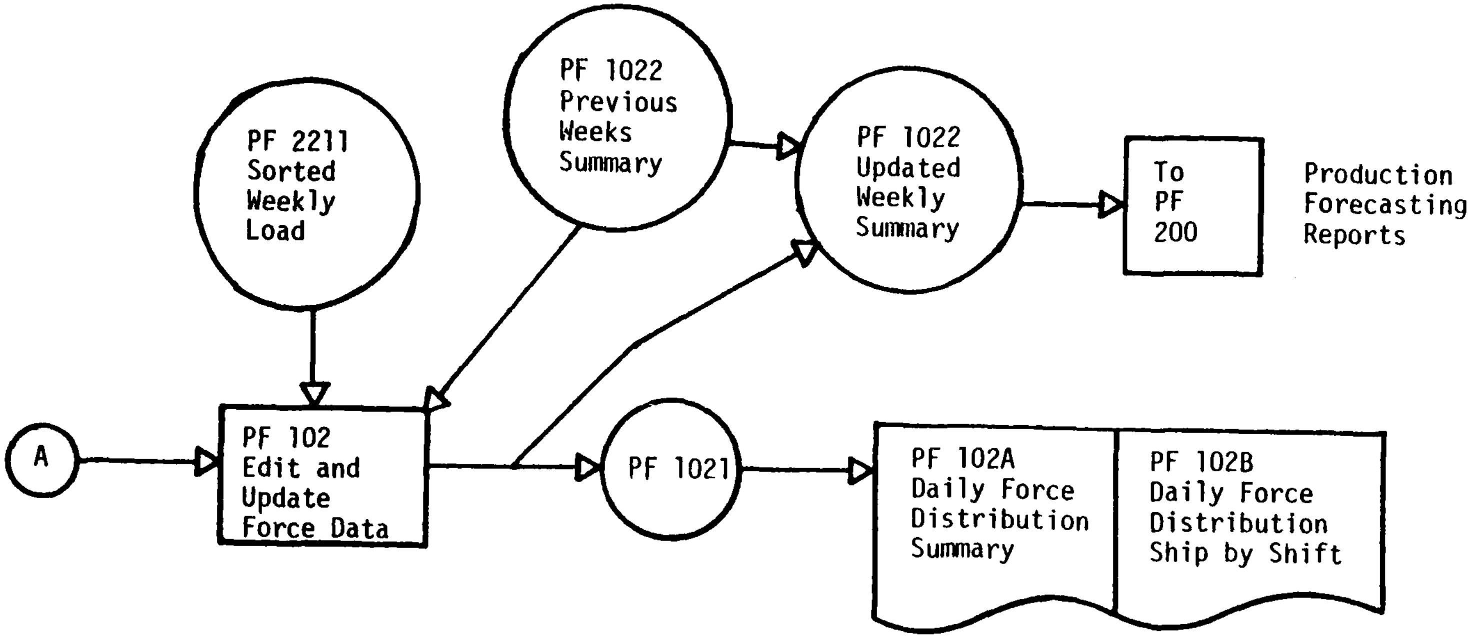


Figure 13

PF-102A GENERATION (CONT'D)



families within that application. The Workload Forecasting Application constains three major files and three report families from which twenty different reports are generated. These reports are summarized in figure 14, the Index of Reports. The purpose of this section is to describe one of those reports, the Daily Force Distribution Summary, PF-102A.

1. PF-102A

The purpose of the Daily Force Distribution Summary, PF-102A, is to assist Production Department Management in the monitoring of daily man-hour expenditures of the various shops and to make comparisons with the available force. The report contains man-days expended, loaded, and forecast for the previous day. This information is given for each ship and shop, and is summed for each availability type and for total shipwork. Total non-shipwork (manufacturing and other productive work, and military support) is also provided for each shop. Shop rolls with related absences, overhead, loans, and borrows are also presented along with resulting available force figures.

Shop planners, shop heads, and group heads will review the report to see if expenditures for the previous day were at levels they expected. If expenditures are consistently below men-per-day forecast requirements, additional manpower assignments may be in order; comparison of available force to men-per-day forecasts may indicate a requirement to borrow additional manpower from other shops or shipyards, hire temporary assistance, or reschedule operations as necessary. This report provides a good short-term day-by-day check on the shop manpower situation.

2. Sample PF-102A

Figure 15 is a sample PF-102A report. This example shows items

Figure 14 INDEX OF REPORTS

REPORT NUMBER	REPORT TITLE
PF-102A	Daily Force Distribution Report, Summary
PF-102B	Daily Force Distribution Report, Ship by Shift
PF-200A	Overhead Distribution Report by Cost Class-Weekly Summary
PF-200B	Overhead Distribution Report by Job Order-Weekly Summary
PF-209A	Scheduled Shop Loading Report, Shop/Work Center
PF-212A	Scheduled Shop Loading Report, Prod. Dept. by Ship
PF-213A	Scheduled Shop Loading Report, Ship by Shop
PF-215A	Workload Forcecast, Ship by Shop or Ship by Code
PF-217A	Workload Forecast/Schedule Load, Shop or Code
PF-218A	Workload Forecast/Schedule Load, Production Department or Design Division
PF-220A	Comments on Workload Transactions
PF-220B	Workload Changes Shop or Code
PF-403A	Planned Workload and Employment Report
PF-405A	Design Workload Forecast, 1 - 12 Months
PF-419A	Workload Forecast, Graph, Shop XX
PF-419B	Workload Forecast, Graph, Prod. Dept.
PF-419C	Workload Forecast, Graph, Shop XX
PF-419D	Workload Forecast, Graph, Prod. Dept.
PF-903A	Master Workload Transaction Report

which would be applicable to a ship undergoing a regular overhaul (ROH) availability only. Items applicable to the other types of availabilities would be included under separate category and then summarized in the TOTAL headings. Twenty-one items of special interest are highlighted for their importance and explained below:

Item	Heading	Identification of Data
1	SHIP/PROJECT	The name of the ship and the hull type and number. In the case of non-shipwork projects, the code name of the project is used.
2	ALL SHOPS	Total man-days expended, loaded, and forecast for all shops.
3		Man-days expended, loaded, and forecast for each shop.
4		Man-days expended, loaded and forecast for each ship with ROH availability type.
5	TOT	Total, Shipwork, Man-days. Figures do not include manufacturing and other productive work, or military support.
6	LOAD	Scheduled Load; Average men-per-day loaded (scheduled and issued), shipwork only, man-days are in terms of will cost.
7	WLF	Forecast, Men-per-Day; Average men-per-day for shipwork only.
8	TOT RO	Total Regular Overhaul; Total number of man-days expended (regular time), loaded, and forecast, plus that expended for overtime (OT) for ships within the availability type.
9	MFG OPW	Manufactured and Other Productive Work; Repoted in man-days for work expended, TOT, loaded, LOAD, and forecast, WLF.
10	MIL SUPP	Military Support in man-days for work expended, TOT, loaded, LOAD, and forecast, WLF.

11	NON-MATCHED	Charges which do not meet assigned level of validation criteria and unreported straight time under eight hours.
12	TOT PROD	Total Production Work; Including shipwork, manufacturing, and other productive work military support, overtime and non-matched.
13	SHOP ROLLS	Total number of workers assigned to all shops, and to each shop.
14	ABSENT	Employees on shop rolls who are not available for performance of productive work.
15	TOT MAINT	Total Maintenance; the sum of work expended for maintenance categories.
16	TOT OPER	Operating Total; sum of the projections/ expenditures incurred for operating costs.
17	LOANS (SHYPD)	Loans, Internal; the number of employees loaned to other shops within the shipyard.
18	LOANS (EXT)	Loans, External; the number of employees loaned to other shipyards, by shop.
19	BORROWS (SHYPD)	Borrows, Internal; the number of employees borrowed from another shop within the shipyard.
20	BORROWS (EXT)	Borrows, External; the number of employees borrowed from other shipyards.
21	AVAIL FORCE (PROD)	Available Force; the number of employees within a shop that are available for assignment to productive work.

H. HONEYWELL 6060 SYSTEM

In 1973, as part of the Shipyard Management Information System improvement program designed to upgrade data processing throughout the Naval Shipyard Complex, Mare Island acquired a multidimensional Honeywell 6060 Information System. The 6060 was especially designed for large-scale

Figure 15

PF-102A DAILY FORCE DISTRIBUTION REPORT, SUMMARY 3

ISSUE DATE 14 JUN 7X
DATA DATE 13 JUN 7X

	1 SHIP/PROJECT		2 ALL SHOPS	06	11	12	17	23	24	26	30	31	35	36	37	38	41	51	56
4	DECATUR	5 6 TOT	436	1	29	8	40		30	17		41		23	23	98	95	14	17
	DDG 0031	LOAD	431		11	4	45		24	22	3	34		50	27	49	122	16	24
		WLF	384		25		33		31	11	1	49		30	27	53	98	9	17
8	TOT RO 7	TOT	1325	4	137	12	38		123	134	9	130		126	110	150	158	69	125
		LOAD	2567	3	199	28	55	6	213	256	29	272		223	300	207	395	119	262
		WLF	1784	7	145		42	1	139	145	24	176		195	226	156	260	54	214
		OT	18		5		5		3			3					2		
9	MFG OPW	TOT	284	18	7		5	12	11	56		42	10	1		6	4	5	107
		LOAD	234	11	3		3	5	2	33		25	10	5		4	4	7	120
		WLF	409	10	5		5	18	18	68	1	50	10	13		8	50	8	145
		OT	11				7			4									
10	MIL SUPP	TOT	74	2	2			9					5	10			45		1
		LOAD	15	2	2			1					10						
		WLF	12	1	1								10						
11	NON MATCHED	TOT	205	6	6	6	6	1	16	14	8	13		36	5	11	51	8	18
12	TOT PROD	TOT	2745	76	260	26	135	40	227	247	17	248	25	204	146	294	370	150	280
		LOAD	2524	55	177	20	88	14	154	259	26	265	30	198	186	287	294	146	325
		WLF	2786	63	244	22	121	34	235	256	13	272	30	234	189	229	382	140	322
		OT	56		5		12		11	12		4					12		
13	SHOP ROLLS		3586	88	366	44	198	49	335	306	22	308	28	261	159	376	469	200	377
14	ABSENT		325	19	35	4	25	5	25	21	3	24		20	14	32	49	19	30
15	TOT MAINT		69	7	10	5	7		7	5		3	3			1	4	3	14
16	TOT OPER		421	7	27	9	25	4	44	33	2	39		34	16	45	54	24	58
17	LOANS (SHPYD)		161		41		18		43	25		3		3		12	12	4	
18	LOANS (EXT)		3																3
19	BORROWS (SHIPYD)		76	21	2					13		5			17	8	2		8
20	BORROWS (EXT)		6														6		
21	AVAIL FORCE(PROD)		2689	76	255	26	123	40	216	235	17	244	25	204	146	294	358	150	280

data handling based on the COBOL language. It relies on an index-sequential method of file processing and incorporates a powerful database management system. Multiprogramming is supported in that up to sixty-three programs may be in concurrent execution. The versatility of the 6060 operating system allows the following features: integration of local batch processing, remote batch, remote access, transaction processing, interactive remote job entry, on-line document handling and time-sharing for maximum system utilization. Memory is organized into 1,024 record blocks, each memory module contains 256 blocks (262,144 words) allowing for over 1.5 million words of main memory. One central processor is in residence with 384,000 words of memory [18]. Other system components and characteristics include:

```
Basic Cycle Time = 500 nano-seconds
Effective Cycle Rate = 16 nano-seconds per byte
Six On-Line Model 181 Disc Units, one additional back-up unit avail-
  able
  Positioning Time = 10 milli-second minimum
                     34 milli-second average
                     60 milli-second maximum
  Transfer Rate = 416,000 characters per second
  Total Removeable Characters = 27.6 Million per disc
  One Character = 6 bits
  384 Characters per sector
  18 Sectors per Track
  6,912 Characters per Track
  20 Tracks per Cylinder
Eight None-Track 1,600 bpi Tape Units, one additional back-up unit
  available
  Rewind Speed = 500 ips
  Transfer Rate = 42,000 bps
  Inter-Record Gap = 1,200 bits (3/4 inch)
  Tape Length = 2,400 feet
Reader Speed = 1,050 cards per minute
Printer Speed = 1,200 lines per minute
```

1. 6060 Operating System

Functions of the General Comprehensive Operating System (GCOS) of the Honeywell 6060 Information System provide for logical programmer and operator interfaces with the software system, provide for a common file protection and access control that is accessible from all processing modes, and maximize system availability through a comprehensive total on-line testing system. To perform these functions with the efficiency required for the MINSY multi-dimensional operations, GCOS serves as the overall manager for the operation of the integrated hardware/software system. As system manager, it is able to achieve maximum utilization of the total hardware system and supervise the multiprocessor/multiprogramming environment - MINSY's normal operating mode. Significant GCOS features that are required to perform these functions are implemented as modules, programs, and subroutines.

a. Functional Components

Major functional components of the 6060 operating system include, with a brief description of each: a startup program package which provides a variety of system startup operations including the loading, initialization, and utility functions required for system startup, or restart following a system fault; system input modules allow for multi-input streams by accepting input from all system input devices into core only when needed; the system scheduler uses the job priorities and classes processed in the system input program to establish a dispensing queue to fit the requirements of the user's operation; the dispatcher keeps as many system components as possible in simultaneous use by selecting the highest priority program that can make immediate use of a processor and/or a peripheral subsystem; the peripheral allocator module schedules and allocates all peripheral devices used by the system; the memory allocation function performed by the core allocator allocates memory space to jobs entered into the system for processing. Operator-system interface messages are also available for exchange between system programs and the system console and are controlled by a GCOS module.

b. Fault Processing

The method by which faults are processed depends on whether the fault occurred within the system or within a slave program. If a system fault occurred, an error message is sent to the system console, and the content of the registers at the time of the fault are dumped. If a noncontrol processor found the fault, it requests an interrupt from the control processor. The control processor puts the noncontrol processor in a DIS (Display until Interrupt Signal) state and takes the dump. If the control processor detects the fault, it puts the noncontrol processors in a DIS state and takes the dump. If a program fault is encountered when operating in the slave mode, the fault causes interrogation of the user fault vectors. If the user specifies a fault processing subroutine, control is transferred via this vector back to the slave activity. If no fault processing routine is specified in the user fault vector, an abort is set into the user program and control is transferred to the GCOS, for fault correction if possible. Faults that can be user processed are memory, divide-check, ovdrflow, command, illegal procedure, fault tag, and derail. Normally a second attempt to process a fault of the last four types will cause the program to fully abort. Those faults that cannot be processed by the user are lockup, parity, operation-not-complete, startup, timer runout, and shutdown.

c. Input-Output Supervisor

The Input-Output Supervisor (IOS) performs the acceptance, initiation, and termination of all input/output (I/O) requests. I/O operations on the system are accomplished by using a memory I/O operation instruction which, when followed by pertinent I/O parameters, give control to IOS to initiate activity on the peripheral subsystems or to the routine handler to perform the I/O. Capabilities of IOS include symbolic-to-physical unit translations which cause symbolic file designators employed by programmers to be converted to absolute physical assignments at execution time. Simulated tape processing on disc simulates the serial mode of data processing normally associated with magnetic tape to be performed on disc which provides a degree of divide independence to the system and allows reduction in program setup time by eliminating magnetic tape use for some files. IOS responds to all interrupts and takes appropriate action thus allowing the programmer to be relatively free of concern for the interrupt system of the computer. IOS maintains queues of I/O commands but will not necessarily select queued commands for execution in the order in which they were submitted unless they are presented by a linked file. IOS maintains awareness of the status of each individual peripheral device in standby and ready modes. IOS verifies that the user has been granted permission for the permanent file access; IOS will also keep a record of the time spent by the processor and each peripheral device for every program executed. These statistics are later recorded on the accounting file and printed on the execution report for later use in billing and system operation analysis.

2. Data Base Manager

Data base manager functions are provided by the File Management Supervisor (FMS) routines which provide for cataloging, control of storage space, prevention of unauthorized access, protection against device failure, partial protection against incomplete or incorrect update, and protection against concurrent usage.

a. Cataloging

Cataloging is the method by which information concerning the file is kept and thus is the basis for all other services. Cataloging services allow files to be created and deleted and their descriptions to be grouped and modified. The FMS administers a structure of mass storage records to keep track of information about files and authorized users. A separate substructure is created for each user to record information about files and authorized users. A separate substructure is created for each user to record information about files catalogued under that user name. A System Master Catalogue (SMC) is employed as an index to these substructures. The SMC has an entry for each user authorized to reference catalogued files, to use the Time-Sharing System, or both. The records in each user substructure are organized to allow hierarchical grouping of files for the user. At the lowest level, there is a file description for each file in which is kept: information to allow mapping from file to source location; specifications by file creator; counts of jobs currently using the file; the information recorded by FMS about the file. At the highest level in the user substructure, there is a User Master Catalogue (UMC) that indexes the substructure for the user. Where there are subordinate catalogues, the UMC indexes each file description. When there are subordinate catalogues, the UMC indexes catalogues as well as file descriptions immediately subordinate to the UMC.

b. *Control of Storage Space*

Although the File Management Supervisor does not specifically manage storage space, as it is managed by a space allocator in the GCOS section, FMS does accept and obey limits on space to be used for both default and overriding specifications on devices to use. FMS obtains space for files to be created and releases space for files to be deleted on fixed devices and on removable structured disc packs that are mounted at the time of the create or delete request. If enough space for creation is not available, the request is denied. If the request is for growth, growth is constrained to the named device, or, if not named, to the remaining device of the same type with space proportional to the current size of the file to be expanded. When the file is created or grown subordinate to a catalogue on a removable structured disc pack, however, space is obtained only from that disc pack either for file create, or file growth. Without such a constraint, the ability to move a file from off-line to on-line would be lost since mounting instructions are issued only for a single pack; the mounted pack cannot be dismounted since it contains the file description. The smallest allocation possible is one Honeywell defined "llink", which is 320 words, 1,280 9-bit bytes, or 1,260 six-bit characters. Other allocation units are integer multiples of llinks of 1, 2, 4, 6, 12, 24, 36, 48, or 60.

c. Protection Against Unauthorized Access

Unauthorized usage of a catalogued file is prevented by means of passwords, permissions, and security locks. A password must be specified for each user at the time a System Master Catalogue entry is prepared. Passwords can optionally be specified for catalogues and files. User passwords, to permit reference of catalogue files, or to use the Time-Sharing System, contain one to twelve combinations of alpha-numeric characters, dashes, or periods. These are requested, in the Time-Sharing System, whenever a user requests admittance to the system presenting his individual name first. A strikeover mask is provided to prevent the password from being visible. Timed passwords are also employed for files or catalogues.

When a file or catalogue is created or modified, the creator or modifier can specify what actions are permitted on the file, catalogue, or subordinate files or catalogues by what users. Both general and specific permissions can be specified for a catalogue to apply to subordinate files or catalogues. Permissions can be specified by anyone, in general, or for specifically named users. When there are several levels of subordination, the permissions at each level are accumulated. Permitted actions include Read, Write, Append, Execute, Modify, and Purge. If a request is received that requires a permission, the permission field is searched for general permissions first, then specific permissions, and then exclusions. Only the creator of a file is considered to have exclusive permission for that file's use.

A file can be security locked to limit allocation of the file. Security locking of a catalogue limits allocation of any files subordinate to the catalogue. Allocation is denied to a security locked file if the request for allocation is from anyone but a user with LOCK permission, or the creator of the file. If a catalogue is security locked, any file subordinate to the catalogue cannot be allocated except to users who have LOCK permission for, or are the creators of, the file. Security locking is performed by a catalogue operation similar to file creation or file modification. It can only be performed by a user who is the creator or has LOCK permission for the file or catalogue being locked. Similarly, removal of a security lock is performed by a catalogue operation that can only be performed by a user who is the creator or has LOCK permission for the file or catalogue being unlocked.

d. Protection Against Device Failure

Six facilities provide differing degrees of protection against common forms of device failure. Either files or catalogues, or both, can be protected: Verifying file writes may prevent data from being written to device space from which it cannot be subsequently read; duplicating a file permits immediate receovery if one or more pages of a file on a device are unreadable, but the recovery time is not as quick as it is from verification; journaling file changes permits recovery if one or more pages of a file on a device are unreadable, recovery time is still not as quick as from duplication; saving a file permits recovery of the entire file, unlike duplication or journaling, the entire file must be restored, since restoration provides the version of the file at the time of the save, the file is generally out-of-date at the time of the recovery. Duplicating catalogues permits immediate recovery if a catalogue is unreadable, duplication of catalogues limits the number of files that require restoring to those contained on the failed device; saving of catalogues permits recovery of an unreadable catalogue, but recovery time is not as quick as it is from duplication, restoring from a catalogue save requires all catalogues and all files referenced from the catalogues be restored, restoring generally provides out-of-date versions of the catalogues as well as the files.

e. Protection Against Improper Update

The File Management Supervisor cannot protect against many possible causes of a file being improperly updated since this would require not only FMS knowledge of the file format, but also knowledge of the file application itself. However, there are two causes of improper file update that FMS can provide protection against. First, when a job that is updating a file terminates abruptly, either because of job or system failure, the file is left in a partially updated condition. FMS is able to cancel these partial updates. Second, for new application programs that have been inadequately tested, FMS provides a way for testing programs against the production file without any danger of damage to the file.

f. Protection Against Concurrent Usage

One of the four available access options must be selected for controlling concurrent allocations to a file. The default option is the NORMAL operation which allows either multiple readers or a single writer. With this option, no interference of one job with another concurrently allocated can occur since only concurrent readers are allowed. Two other options, CONCURRENT, and MONITOR, allow both multiple readers and multiple writers to be allocated at the same time. With MONITOR, reads and writes to the file are controlled so that any that might interfere with the operation of another job are either prevented or delayed until the chance of interference is past. With CONCURRENT, however, no such control over reads and writes is exercised by the File Management System. The chance of interference of one job with another must be tolerated, controlled by other means such as programming within each job or in a common file content manager, or at least controlled enough to decrease the chance or types of interference to a tolerable extent. One final option, READ WHILE WRITE, allows multiple readers and a single writer. The writer may interfere with the operation of the readers, but since only a single writer is allowed, interference between writers which might damage the file content cannot occur, and, of course, readers cannot interfere at any time with the operation of the writer.

I. INCORPORATING ADDITIONS TO MINSY's MIS

Any management information system that remains static and merely provides information to users that support existing methods of operation is not being used to its full potential. Managers of a system such as the Shipyard Management Information System at Mare Island Naval Shipyard must seek out user problems to determine whether or not the development of new managerial systems together with supporting information system data and reports is needed and can be cost-effective. Two examples follow which demonstrate how this has been done at MINSY. A summary of procedures utilized at Mare Island for local system improvements is also included.

1. WOJO

One of the persistent problems which has prevented effective shipyard planning and production control has been the failure to integrate all planning and estimating, design scheduling, and material ordering functions of an availability in one production-oriented work package. WOJO, or the Work Oriented Job Order System, is an integrated planning methodology for developing, managing, and controlling industrially oriented work packages for shipyard repairs and alterations during overhauls, conversions, and new construction [19]. Under WOJO, work is planned and packaged in the manner in which it is to be accomplished by the various shops. This is actually done on a system or area basis such that a single Job Order issued to a shop for accomplishment may be composed of repair items, SHIPALTS, ORDALTS, and special project tasks all considered to be one job.

WOJO requires that shipyard planning and scheduling activities for an availability be coordinated and integrated during the work scoping period. As defined by WOJO, work scoping requires all availability planning inputs (design plans, planning and estimating, material ordering) to be specified, scheduled, and monitored as a whole - not as individual functional items. Accordingly, WOJO requires active participation from Design, Planning and Estimating, Scheduling, and Supply Department personnel, as well as representatives from other specialized shipyard organizational elements such as Combat Systems and Nuclear Power on an ad-hoc basis. The WOJO system is employed for those ships where much of the work on a system, or in a single location on board the ship, involves several closely related customer work requests that can best be accomplished as a single integrated effort by the work force.

Twelve MIS transaction codes are required to enter WOJO inputs to the Shipyard MIS. These are input from three source documents: the Industrial/Financial Control Transmittal Sheet is the primary document, the Work Estimate Sheet and the Job Order Document are secondary inputs. Data entries must be complete and accurate in order to ensure that reliable data are recorded in the pertinent MIS files and are subsequently reflected in the MIS output reports. The Industrial/Financial Control Transmittal Sheets are prepared by the lead planner who enters approved KEYOPS, man-hour cost estimates, scheduled dates, material cost estimates, and percentage prorations/translations as they are applicable to the various shops scheduled to perform the integrated effort. The Work Oriented Job Order System outputs are reflected in the Shipyard Management Information System Financial Subsystem. Nine reports are affected by WOJO transactions. These reports include items concerning proration/translation percentages for charge-back procedures, man-hour allowances, a record of all such transactions, distribution percentage changes, and cost control.

2. Ship Work Control System

The Ship Work Control System (SWCS) is a computer-based system for maintaining listings of all outstanding and completed non-nuclear deficiencies, test documents, work authorized by the work permit system and other miscellaneous documents or certifications for each ship undergoing overhaul or repair at Mare Island Naval Shipyard [20]. The SWCS upgrades the former Non-Nuclear Composite system, see reference 21, to an on-line system of direct computer entry and retrieval. This on-line system utilizes remote terminals to gain entry to the data base where information is stored. The access for retrieval of information is through a set of standardized codings available in detail in reference 20.

The Ship Work Control System is managed by the Ship Work Control Center (Code 356) to provide, on demand, convenient locally generated management reports to assess the status of remaining work on non-nuclear shipboard systems. SWCS is a production-oriented system which keeps track of the numbers of various types of source documents outstanding on a given ship. These source documents are each a source of some kind of shipyard action on the system involved. Each source document is assigned to a responsible code, to the shop supervisor level, for action. It is additionally identified by a unique report number, Key Event, compartment, deck, and location. SWCS contains a strong inherent managerial accountability and control device in its requirement for Shop Supervisors to verify completion of the action called for by a given source document, and to sign the Code 356 copy of that document before the document can be cleared from the computerized system reports. This requirement, self-imposed by MINSY, serves to increase supervisory involvement, knowledge, and accountability for work status determination and lends considerable credibility to SWCS reports.

a. SWCS Terminal Operations

To provide the on-line capability, remote terminals, which are directly connected to the computer via telephone line, are spotted at various locations throughout the shipyard, see figure 16. These terminals contain a cathode ray tube for message display, a keyboard for data input and data base inquiry, and an eighty character wide printer capable of printing data which is sent to the terminal. These terminals allow for instant inquiry of the status of items on the data base. To provide for large volume reports, the Ship Work Control Center is equipped with a 132 character, 300 lines per minute printer, and a XEROX 7000 Computer Forms Feeder which provides for the printing of large volume 132 character-wide reports and their subsequent reductions to 8 x 10 1/2 inch size paper.

Figure 16 SWCS TERMINAL LOCATIONS

Code Assignment	Bldg/ Floor	Terminal Number	Function/Location
100	521/1	23	Code 100 Conference Room 1069
113	229/2	1, 25, 27	Data Processing Office
133.11	45/2	16	Non-Nuclear Inspection Division Records Center
191.2	55/2	15	Combat System Test Division
280.48/365	742/2	19	Ocean Engineering Test Center
290.1	69/2	14	HP&A Test Operation Branch
330	108/2	6	Drydock #1 Ship Supt. Office
330/365	Barge YRR63	7	Ship Superintendent Office
330/365	69/1	8	Berth 9 Ship Supt. Office
330	163/2	9	Berth 7/8 Ship Supt. Office
330/365	Barge YC-1449	10	Ship Superintendent Office
365	163/1	11	Berth 7/8 SWCC Satellite Office
330/365	664A	12	Berths 17/18/19 Ship Supt./ SWCC Satellite Office
330	69/2	18	Repair Officer Conf. Room
330/365	BAB	22	Drydock #3 Ship Supt./SWCC Satellite Office
365.1	69/2	2, 3, 4, 5 & 26	Ship Work Control Branch Main Record Center
920/956	46	20	Code 956 Office Area
930/938	128	21	Code 930.44 Shop Planning Office (938 Planners)
938TCC	69/1	17	938 Shop Test Control Center
950	866	13	Code 950.4 Planning Office

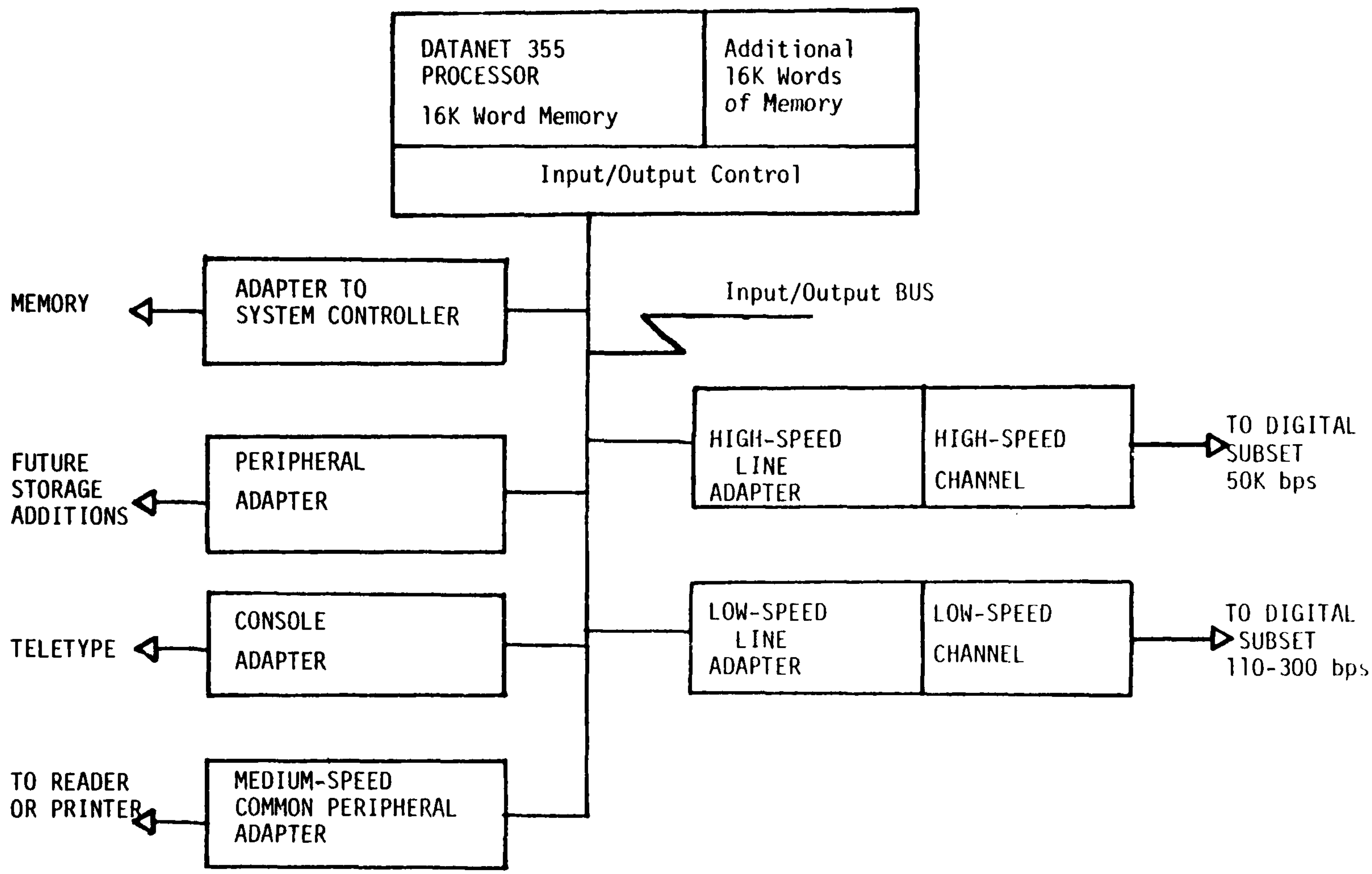
b. DATANET 355

The DATANET 355 Front-End Network Processor (FNP) is a Honeywell provided high performance, stored-program FNP designed to match the large-volume communication needs of the 6060 multidimensional information system in general and the requirements of the Mare Island Naval Shipyard Ship Work Control System in particular. It features total integrated circuit logic construction and a memory size of sixteen or thirty-two thousand words on a memory cycle of one micro-second. DATANET can accommodate data of variable word lengths of six, nine, eighteen, or thirty-six bits. All data words are individually addressable to allow highly efficient processing of tabular data. Ninety-eight instructions in an eighteen bit format are provided with one single-address instruction per word. Three index registers and multilevel indirect addressing, with indexing at all levels, give an addressable storage to thirty-two thousand words.

The system organization of the DATANET 355 FNP follows the pattern of the 6060. It is a storage-oriented computer with its own independent memory, processor, and input/output modules, see figure 17. These three basic modules are independently timed and operate asynchronously with each other. The processor and the I/O Controller, the active units, process data at their own rates and erquest cycles from storage modules, passive units, as the need arises. Only when the processor executes certain input/output instructions must the processor and the Input/Output Controller communicate with each other.

Input/Output is designed to facilitate efficient real-time concurrent servicing of multiple terminals and peripheral devices. Up

Figure 17 DATANET 355 FRONT-END PROCESSOR



to sixteen adapters can be provided to accommodate a total data transfer rate of up to 500,000 words per second (with six to thirty-six bits per word). Sixteen levels of priority interrupt, with sixteen sublevels per level and corresponding interrupt masks, are provided. As a module of the 6060 system, DATANET is capable of simultaneously handling up to two-hundred teleprinter, or thirty-two remote batch users, or thirty-two CRT subsystems or an appropriate mix of the three classes.

3. MINSY MIS Improvements

The Director of Management Engineering (Code 140) at Mare Island Naval Shipyard serves as the focal point for Shipyard MIS matters including performance of special studies and projects in the fields of management information systems and related automatic data processing system requirements [17]. Code 140 coordinates requests for improvements to the Shipyard MIS, as they may related to the total shipyard complex, with the Data Processing Office and forwards the required information to CASDO and NAVSEA in accordance with NAVSEA directives. The Director of Management Engineering also serves as shipyard liaison with CASDO and NAVSEA 073 as required to accomplish approved Shipyard MIS requirements [2].

On the local, MINSY, level, Code 140: assists local department heads in determining suitable methods for satisfying departmental informational requirements; audits the installed MIS as necessary to assure that it is serving its designed purpose and is operating effectively; annually reviews distribution and use of all ADP reports to ensure minimal distribution consistent with local departmental information requirements; reviews proposed local ADP reports, additions or modifications to the Shipyard MIS for necessity and to determine the optimum means of satisfying requirements involved in order to obtain maximum cost-effectiveness for both the affected department and the Data Processing Office.

When requesting local programmer or data processing services requiring: the development of a new data system, the modification of an existing system, other than correction of program deficiencies; or the generation of new or modified reports from the existing system, the cognizant department head is to provide the Director of Management Engineering a cost/benefit analysis. A feasibility study will be prepared using Code 140 and the requesting department's personnel, recognizing that the Shipyard Management Information System's development, implementation, and monitoring are under technical and coordination control of the Director of Management Engineering.

Modification requests must state specifically what the proposed revision is expected to accomplish along with the benefits, including dollar cost savings, and relate this to an established functional or organizational responsibility. Cost savings can be of three types: direct savings resulting from the computer performing tasks that are currently done manually, or a new reauirement that is cheaper to perform under ADP as opposed to manually, this type of saving is the best justification providing there is a genuine need for the generated output; indirect savings result from productivity improvement as a result of the use of additional or more timely data; and intangible benefits which improve morale or work quality that cannot usually be quantified. The requests must also include anticipated problems and recommendations for the resolution of those problems. Lastly, organizational charts delineating the decision points to be satisfied by the proposed modification in relationship to the cost/benefits of the present methods must also be included. It is with this whole spectrum of requirements (paperwork) that only those modification proposals that will genuinely benefit the Shipyard MIS will be initiated.

J. PHYSICAL SECURITY

Since Security of the internal computer data base was adequately discussed under the Data Base Manager section of this chapter, this section will address physical security precautions implemented for protection of the data base and the data processing equipment in the Data Processing Center at Mare Island Naval Shipyard. The center is manned twenty-four-hours-a-day, seven-days-a-week every week of the year with the exception of Thanksgiving and Christmas Days. When the center is not manned, motion and temperature alarms are activated to monitor unauthorized activity. Each member of the data processing staff is known by sight by every other member of the staff. Report disssemination from the DP Center is carefully controlled in that only authorized guard-mail or messenger personnel from the affected departments are allowed to remove outputs from the center.

Terminal security is provided by the previously mentioned password system, which is changed periodically, and the security "kernal" methods alluded to that are resident within the operating system. Security of each terminal is also provided by each location within which a terminal resides. A time lockout system for terminals has been suggested but not yet implemented. The highest Department of Defense level of information contained within the system is "Confidential". Annual, and as requested, security inspections of the system are also provided by the Security

Department. Mare Island Naval Shipyard itself also provides overall security in the form of a contingent of United States Marine Corps personnel stationed at MINSY and a Mare Island Police Force. Fire protection is provided by smoke and heat alarms. A "wet" fire suppressant system is installed with plans to implement a halogen-based system in the future. There is only one entrance to the computer and data storage room, which is secured by a cypher lock system. The data storage room is separated from the computer room by a heavy steel door. Finally, the building itself is an innocuous appearing structure with no signs labeling it as a data processing site. There are no windows in the computer equipment or storage rooms which are further separated from the outside world by two fire doors in addition to the cypher door access.

IV. DISTRIBUTED DATA PROCESSING AT MARE ISLAND NAVAL SHIPYARD

A. INTRODUCTION

It is recognized that distributed data processing as defined in chapter I does not currently exist at Mare Island Naval Shipyard. What does exist is a front-end network processor, the DATANET 355. The use of a front-end communications processor associated with a large computer is an accepted practice in modern data processing. Few large-scale systems do not rely on data communications to serve at least some of their uses. While some large corporations have instituted a policy of using large minicomputers and medium-scale computers rather than large computers to meet all corporate distributed data processing needs, most corporations have preferred to build outward from a well-established central computing facility. This approach to DDP may not be bold, but it is sensible. By retaining the large systems, users protect the investment that has been made in software, and especially since the price wars of the spring of 1977, they can point to dramatic price decreases of large system hardware as justification.

The large systems role in distributed processing may be any combination of the following: host to a time-sharing network; guardian of the corporate data base; as a computational resource for research and development users; and, host to a mammoth batch processing system. If these categories do not sound exactly like distributed processing, it must be remembered that the work accomplished in a DDP system is basically no different from that which was done before distributed processing - it is the execution mode that is different. For most users, the preferred approach to distributed processing is to follow a hierarchical scheme, with the large system as the pinnacle of a mountain of smaller computers and terminals. The large system has the ability to construct the complete corporate picture from the jigsaw of divisional and departmental pieces. This is the direction that this section of the presentation will follow. It will be shown how an effective distributed data processing system can be created from selective addition of equipment to the data processing configuration currently employed at Mare Island Naval Shipyard.

B. PROBLEMS WITH THE CURRENT SHIPYARD MIS

The standard Shipyard Management Information System as implemented at Mare Island Naval Shipyard contains a proven set of programs that five of the eight members of the Naval Shipyard Complex have used for thirteen years. The other three shipyards have utilized this version of the Shipyard MIS for five years. However, there are some shortcomings to the system, some relatively minor, others of a more serious nature, that can be readily recognized.

1. Programs

Current application programs are designed specifically within the constraints of the second generation equipment employed in the shipyard complex prior to the acquisition of the Honeywell 6060 equipment. These applications are rigidly structured with data that is intended for use within the Shipyard MIS processed in a batch oriented manner. Since each application area within the Shipyard MIS normally requires several files to fulfill its mission, application maintenance costs are relatively high.

As a result; the data that is provided to the various users is somewhat behind the normal business cycle. The user does not have direct access to his data once it has been submitted to the Data Processing Office for inclusion in the Shipyard MIS; he must wait for that office to provide him with a printed report to be delivered at some future time. Also, the same data may be found incorporated into multiple applications wherever it is used.

2. Internal Reports

One of the concepts of a Shipyard Management Information System, as mentioned in chapter II, concerned the grouping of similar reports into report families based on the manner in which information is sorted. The major difference to be found within a report family center around whether the information is sorted by ship, by shop, or by work center. As an example, the PF-102A (Daily Force Distribution Report, Summary) and the PF-102B (Daily Force Distribution Report, Ship by Shift) reports are both generated from the Workload Forecasting Application within the Industrial Subsystem of the Shipyard MIS. The block diagram of the generation for those reports was presented in figures 12 and 13. As can be seen, these reports utilize the same inputs, same sorts, same control and verification programs, and same editing procedure. The only difference is that the PF-102B report will provide data concerning the total number of man-days expended for waterfront work per overhaul type, while the PF-102A report does not directly differentiate waterfront from other productive applications. It would be a relatively simple matter to provide another horizontal row for the PF-102A report in which waterfront information for each shop was presented, thus eliminating one redundant report. Similar examples of redundant reports abound throughout the Shipyard MIS report structure.

3. Additional Application Requirements

Expansion of the Shipyard MIS to include features for Quality Assurance, tool control, and material process control need to be implemented as discussed in chapter II. Inclusion of a Quality Assurance Application within the Industrial Subsystem would reduce this manual data-handling burden supporte dby shipyard personnel. A completely automated inventory and control system for expensive and portable (pilferable) hand tools utilized in nuclear work would assist in the reduction of tool "loss" and allow some of the budget currently designated for tool replacement to be deployed elsewhere. The application could be entitled "Tool Control" and be placed within the Material Subsystem of the Shipyard MIS. A material process report program should be included within the Industrial Material Application which updates direct material item transactions not only upon receipt of materia; but whenever the location status of DMI material changes.

4. Greater Capabilities

A need exists to achieve greater capabilities from the Shipyard Management Information System. Some of those additional capabilities are: the ability to obtain immediate projections as to the impacts of an overhaul schedule change on production schedules, manpower requirements and availability, and on facility loading; automated print-out of job order and KEYOP instructions, material staging lists, and job material lists at the point of use and time of need; continual on-line status for all shop store and direct material items that are on order, in stock, or being inspected; on-line expenditure and progress data for any ship availability at the job order, KEYOP, and/or summary level; automated retrieval of applicable historical data to use for planning of new work and estimating the cost thereof, and for the forecasting of future workload; and an overall dynamic shipyard study capability.

5. External Reports

In addition to needs that are identified to serve the requirements of management at various levels within the shipyard, there has been a definite trend in increasing requirements for information on shipyard operations from many levels within the Federal Government. Many of the requirements are for one-time pieces of information; however, most of these one-time requirements have a habit of becoming continuing requirements either for a change in an existing reporting system of for new reports. No relief from these trends for greater regulation from higher authorities and for more reporting is foreseen. Rather, the trend seems to be toward ever-increasing regulation. A database system that is more flexible than the currently employed rigid batch processing oriented programs is needed to provide the capability of easier response to the increasing regulation and reporting schemes that are predicted.

6. Timeliness

Although data may be delivered to the Data Processing Office early in a workday, it is commonly not available for managerial use until sometime the following workday. There are two reasons for this: first, routine Shipyard Management Information System processing at Mare Island occurs on the swing shift (1600-2400), after the normal workday is completed, this procedure helps to ensure that all transactions that are dedicated to updating a particular file are present at the time the file is updated; and second, guard mail or messenger pick-up of reports does not occur until the beginning of the next worday, this results in an inherent delay in transporting of reports from the Data Processing Office, where they originate, to the user, where they are employed. Although many reports are prepared daily, others are available less frequently - weekly, monthly, semi-annually or annually. These latter reports are usually of a summary nature reporting total information of a type that has occurred since the last similar report. However, managers still are not able to revidw overall summary information that they may desire until these summary reports are normally available, unless they wish to submit a special request for them. Historical data, unless managers have retained all of their old reports applicable to the information they may desire, is also not readily available in the formats necessary to meet changing demands from these customers.

C. DISTRIBUTED PROCESSING AND MIS

Many of the goals and objectives of the Shipyard Management Information System at Mare Island Naval Shipyard and the goals and objectives of a distributed data processing (DDP) system are directly related. In general, the goal of MINSY's MIS is to provide operational and predictive information to assist all levels of shipyard management in the decision-making process. It desires to provide information that is accurate and timely, in an easily understandable form that is practical, useful, and meaningful to these shipyard decision-making efforts.

1. Scope

As events occur within the Shipyard Management Information System, a distributed data processing system is able to process data concerning various elements of shipyard operations. Distributed data processing systems may be programmed to generate the wide variety of reports which provide operational and predictive information in either a real-time format, as displayed on a cathode ray tube, or present it in hard copy, depending on managerial requirements. Distributed data processing systems are able to take into consideration many aspects of any industrial type of activity which depends upon the cycle of forecasting, planning, scheduling, production and evaluation. Each of these processes is given its processing priority and logical position within the distributed system by virtue of the employment and type of equipment available at each processing note. Feedback requirements of the Shipyard MIS are provided by virtue of the DDP link communications capabilities. A distributed data processing system is able to provide the basic tools necessary to manage shipyard operations with as great, or even greater, efficiency than that provided by the current Shipyard Management Information System.

2. Concepts

Several of the concepts upon which the Shipyard Management Information System at Mare Island Naval Shipyard is based are readily implemented by a distributed data processing system. The large volume of data flow experienced within the Shipyard MIS is as promptly automated and controlled by a DDP system as by any other management information system. Managerial philosophies of the Department of Defense and Naval Sea Systems Command may still be reflected in a distributed system. Since a distributed data processing system allows for on-the-spot information formatting, shipyard managers are able to design the format of the reports they prefer to utilize at their processing sites, as long as standardized reports are still available to the remainder of the shipyard. Since first-line supervisors have the primary responsibility for quality inputs under a DDP system, as well as under the Shipyard MIS, this concept does not change. Local shipyard control of the development of raw data and report frequency is retained. Report sorting under a DDP system is essentially the same as under any other management information system.

3. Adaptability

A management information system is adaptable in that it is able to recognize and react rapidly to changes in technology and customer requirements. A distributed processing system allows for the upgrading of functions and performance in small increments, with low corresponding cost, through its extensibility characteristic. A minimum and a maximum size in conjunction with the number of permitted increments in order to achieve a future desired performance level may be specified and arranged for with initial system design.

The reconfiguration capability of a distributed data processing system enhances this adaptability requirement in that the system can be dynamically altered to provide resource services directed toward satisfying unique requirements. Normal operations are not significantly affected by virtue of these variations and the system is able to continue to function in its routine manner until those dedicated services are returned to network control. Since hardware to enhance processing is apportioned throughout the nodes of a distributed system, technological innovations can be implemented at the sites that are not only most convenient, but logically structured and decicated to whatever facet of processing the innovation purports to enhance. This method of incorporating technological changes results in fewer disturbances to normal operations since the entire processing system does not have to be shut down in order to install the change. It is also physically easier, normally, to implement a change to a processing system at a satellite node than it is at a central processing facility.

4. Integration of the MIS Functional Levels

Integration of the six levels of a management information system is enhanced by a distributed data processing system. Although processing nodes may be located at sites dedicated to any one of the six MIS levels of planning, forecasting, control, modeling, computing, or data administration, the network operating system resident within the distributed data processing system ensures that the jargons, techniques and data employed by those specialists are integrated into the total system configuration allowing for achievement of the overall objectives of the Shipyard MIS in the most expeditious manner. Each functional level of the MIS is able to exploit the various resources available at the other functional levels within the Shipyard MIS through the capabilities of the NOS in order to attain their common goal.

5. Primacy of Managerial Decisions

Retention of the primacy of managerial decisions within the Shipyard Management Information System is intensified in a distributed data processing system. Information is available to managerial personnel soon after it is entered into the system. Programs resident within the distributed system may be dedicated to the tedious work of data searching, calculating, information summarizing and data comparisons. These facilities of the system will free the decision-makers to: make appropriate conclusions from the recognition of problem areas; generate relevant assumptions; define criteria; and, evaluate alternatives. Those processes, in turn, permit the same managers to perform the creative work of management, decision making. The distributed data processing system is a tool by which managers would be allowed to concentrate on the necessary decision making practices, not the processes by which the information was presented.

D. EQUIPMENT ACQUISITION

Regulations originating from Federal agencies control every phase of a computer's life-cycle in the government - from the initial planning stages, through acquisition of the system, to the eventual disposal of the unit. These regulations apply not only to the actual computer, but also to peripheral devices such as disc units and terminals. No less than one public law, eight Office of Management and Budget circulars, forty-four Federal Information and Processing Standards, twenty-eight Government Accounting Office reports and studies, and a multitude of other directives and regulations have been published to guide the Federal automatic data processing manager in the acquisition of general purpose, automatic data processing equipment (ADPE) in the Navy.

Without elaborating on the total procurement process, from considering only the volumes of regulations concerned, it is obvious that to simply follow the rules of acquistion is a time-consuming and complex process. In addition to the guidance provided from the previously listed regulations, each Federal agency has developed its own implementing directives and instructions to insure compliance with that multitude or rules and regulations. Often, rather than clarifying or attempting to simplify procedures, the local agency regulations only serve to confuse and complicate the procurement process. As a result, many activities having a real requirement for a relatively minor piece of computer hardware become confused and resentful when faced with that tangled array of rules and regulations. For a large computer installation project, it is estimated that up to four years are required from concept formulation until the commencement of the actual acquisition. Depending on the complexity of the system, an additional nine months to two years is then required to conduct the actual acquisition. This results in a total cycle time of approximately five to six years from the concept formulation stage until completion of the acquisition. With six to eight years being the generally accepted figure for the time between successive computer generations, equipment is often out-of-date before a new system becomes operational. A Honeywell representative has estimated that the Federal Government process takes four times as long as a civilian commercial procurement. Peter F. McCloskey, a former president of the Computers and Business Equipment Manufacture's Association, stated that the Federal acquisition process ". . frequently results in procurement of technology that is obsolete because of the time it takes to implement purchase." One estimate has claimed that, in 1977, sixty-eight percent of the Department of Defense ADPE inventory was obsolete, as compared to a thirty-five percent figure for private industry [22].

It is not the purpose of this presentation to describe the detailed procedures required for the acquisition of equipment required to support the implementation of a distributed data processing system at Mare Island

Naval Shipyard. It is acknowledged that the paperwork and justifications required for such an acquisition are beyond the scope of the basic justifications presented: how distributed data processing supports the goals and objectives of the Shipyard MIS; how DDP is able to alleviate some of the shortcomings within the Shipyard MIS: and, how distributed data processing is able to perform the required management information system functions of the shipyard in an efficient and responsive manner. Much more detailed analyses would be required, including cost specifications and demonstrable savings, prior to any consideration being given to the acquisition of any of this type of equipment. For purposes of this presentation, it will be assumed that the decision to "go distributed" has been made by proper authority. It will also be assumed that the implementation of the distributed system is to be accomplished using available Honeywell devices, incorporating them in the 6060 system currently installed at Mare Island wherever possible.

E. PERSONNEL PREPARATION

Most employees, including supervisors and managers, are reluctant to see major changes made in their departmental organization and work flow. Knowledge about an operation that has been built up over a long time period breeds familiarity and confidence. Change brings the unknown and associated apprehension based on a lack of knowledge and confidence in that unknown. To avoid being unprepared, and to overcome the apprehension of personnel, the implementation of distributed processing must be approached in a planned and orderly fashion. There are several approaches available to develop policies and prepare personnel for, and to improve the acceptance of, DDP within the Data Processing Office and Mare Island

Naval Shipyard.

1. Education

An important initial step is to be certain that affected parties within the organization have the same understanding of what distributed data processing means and what it can do for the organization. Often customers and data processing professionals are educated by a vendor advertisement, a news review of limited scope, or a biased magazine article. These may have conveyed misconceptions about DDP technologies and capabilities which may have curtailed its general acceptance and make it difficult for the individual to objectively evaluate DDP use in a variety of different applications. On the other hand, different misconceptions may have given the potential user unrealistic expectations of DDP.

The best way to eliminate this problem of misconception is to educate all parties concerned with the operation of the Data Processing Office. Any number of educational methods, or combinations of methods may be employed [23]. These methods are outlined in figure 18 with the program, source, benefits, and disadvantages of each summarized. The use of this awareness education in distributed data processing can give all attendees a common reference point. It should not be expected, however, that such education will force everyone to think alike. If most of the people that are involved in the implementation of DDP have been through the same educational program, the professional data processing staff is able to use that material as a basic for building its rationale for a specific configuration to be employed within the shipyard.

In addition to the basic orientation course provided to all

Figure 18

EDUCATIONAL METHODS

EDUCATIONAL PROGRAM	SOURCE	BENEFITS	DISADVANTAGES
INTERNAL SEMINAR (ONE TO TWO DAYS)	TRAINING UNIT	INTERNAL CONTROL OF CONTENT	VERY COSTLY TO PUT TOGETHER BIASED COSTLY TO KEEP CURRENT
PUBLIC SEMINAR (ONE TO THREE DAYS)	UNIVERSITIES OR PROFESSIONAL TRAINING TEAMS	COMPLETE PROVEN EXTERNAL VIEW OF THE SUBJECT	COSTLY AND TIME CONSUMING TRAVEL COSTS
PACKAGED EDUCATIONAL PROGRAM	VIDEOTAPE ORGANIZATIONS	LOW COST AND EASE OF USE	MAY BE TOO ELEMENTARY
INTERNAL PRESENTATION OF A PUBLIC SEMINAR (ONE TO THREE DAYS)	UNIVERSITIES OR PROFESSIONAL TRAINING TEAMS	COMPLETE, PROVEN PROGRAM; LOW PER-STUDENT COST; NO INTERNAL INVESTMENT	SCHEDULING ATTENDEES MODIFYING CONTENT TO FIT THE ORGANIZATION
USE OF A COMPREHENSIVE TEXT OR ARTICLES WITH A SELF-STUDY GUIDE	BOOK PUBLISHERS JOURNALS INDIVIDUAL RESEARCH	LOW PRICE CAN BE DONE INFORMALLY	NO ASSURANCE OF COMMON LEVEL OF USE OR LEARNING

interested parties, data processing professional staff members that are to be responsible for the total implementation and operation of the distributed processing system within Mare Island Naval Shipyard will require more detailed knowledge of DDP in general, and the Honeywell Information System as it includes a distributed data processing format, in particular. These subjects and level of knowledge desired are summarized in figure 19. In the education of the data processing staff, information may have to be sought from a number of different sources since no one source is capable of providing the complete sphere of information required. These sources should be selected, used, and balanced to suit the needs of the staff. They include: professional seminars; hardware vendor training; professional and vendor literature; visits to sites where distributed processing is in use; attendance at relevant professional conferences; and, self-study materials.

2. Database Administrator

The database administrator (DBA) is an organization's leader in the planning, design, development, implementation, testing, documentation, operation and maintenance of the entire database environment. The functional orientation of the database administrator is usually characterized as both technical and administrative in nature. There is also a promotional aspect inherently present in that the DBA represents database administration concepts to all participants and coordinates all database activities among managers, analysts, systems and applications programmers, and, of course, the users. Because database administration activities often impact across organizational boundaries, the DBA position becomes sensitive, and the prudent database administrator must be shrewd

Figure 19 DDP DISCIPLINES

SUBJECT	LEVEL OF KNOWLEDGE
DISTRIBUTED SYSTEMS DESIGN ALTERNATIVES	OPTIONS AVAILABLE BENEFITS AND LIMITATIONS OF EACH ALTERNATIVE APPROACHES USED BY OTHERS
COMMUNICATIONS NETWORKING	NETWORK SERVICES AND PROTOCOLS HONEYWELL CAPABILITIES CONTROL PHILOSOPHY
TOTAL HONEYWELL EQUIPMENT CAPABILITIES	OVERALL SYSTEM INSTALLED EXAMPLE OPERATIONS AT VARIOUS DISTRIBUTED LEVELS OF PERFORMANCE MINI AND MICROCOMPUTER TECHNOLOGY
DATABASE TECHNOLOGY	DISTRIBUTED DATABASE CONCEPTS CONTROL, RECOVERY AND AUDIT OF FILES LOGICAL STRUCTURES AND ALTERNATIVES FOR DATA BASE DESIGN
USER OPERATIONS	EQUIPMENT OPERATION AND DATA PROCEDURES TO BE USED AT DISTRIBUTED LOCATIONS USER TRAINING REQUIREMENTS

in discerning jurisdictional questions and conflicting mission requirements.

a. Database Adminstration Concepts

Database administration, by necessity, encompasses all of the technical and managerial activities required for the organizing, maintaining, and directing of the database environments [24]. A database environment consits of the database itself, which may include non-automated as well as automated information, the database administrator, who will actually manage this environment, the software tools used in database administration and data processing, and the users of the database. The main goals of database administration are to: optimize usage of data in a shared database environment; incorporate a systematic methodology for the centralized management and control of data resources; and, balance any conflicting objectives with respect to the parent organization's mission and the overall economy of information handling.

Several key requirements for effective database administration exist as follows: senior management must be strongly committed to the concept and support it fully; the database administration staff must be technically competent; and, there should be team participation in the database concept by the DBA, the technical staff, senior management, and the users. Efficient database administration can provide several significant advantages: the actual database can be better managed especially in the context of centralization of database control and the sharing of resources; data independence will be realized by virtue of controlled definition, design and implementation of the database; data redundancy and inconsistency will be reduced by the assessment and prioritization of conflicting requirements; data integrity will be realized when standardization of usage and enforced security regulations are employed; and, increased responsiveness to the various user communities can result from the better controlled and more up-to-date information that an efficiently administered database will provide.

b. Database Administrative Functions

The following list, although not exhaustive, presents some of the basic functions of a database administrator. The DBA should be able to identify and define common data elements. This recognition needs to include the relationship between data elements and other components of the system such as programs and files. These conceptual definitions should be based on a clear understanding of each user's requirements as well as the needs of the overall parent organization. Whenever possible, the DBA needs to use a data definition language to define and structure the database. It is also within the realm of DBA responsibility to review and monitor data standards. Should the need arise for dynamic alteration of the database, then the DBA must initiate it, redefining the database, or any part of it, with a minimum of disruption and inconvenience to the users.

The database integrity function is related to the DBA's responsibility for the correctness and accuracy contained within the database. This can be achieved through the use of validation checks, stringent access procedures, periodic data dumps, backup and recovery procedures, as well as well-defined audit procedures. The relationship between the DBA and database security is a cursory one. He must, however, ensure that steps have been taken to guard against unauthorized access to the database for purposes of unauthorized update, copying, removal or destruction of any part of the database. Often security and integrity requirements are combined into one software system which will implement procedures designed to simultaneously perform both functions.

The database administrator must be held responsible for the continued well-being of the database. In this capacity, it is his responsibility to maintain and update database definitions and documentation including the data element dictionary. If database performance monitoring and evaluation activities indicate that the database is no longer effective or efficient in its present configuration, then redefinition, redesign, or restructuring activities may be indicated. It is the responsibility of the DBA to advise higher authority when this requirement manifests itself, and to ensure that minimum disruption of user services result.

The database administrator should interpret and administer upper level management policies as they are related to the database, and define rules of use and access constraints for the database. Additionally, the DBA should be held accountable for review and approval of new data definitions and the enforcement of data standards. These enforcement activities include: determination of compliance with established standard usages; development of database content, organization and storage control procedures; and, responsibility for access control and security of the database as previously mentioned.

c. Benefits of the Database Administrator

Adoption and utilization of database administrator concepts as vested in the database administrator dramatically improve the effective ness of an organization's data processing efforts since a focal point is firmly established for the responsibility, management, and control of total data resources. Some of the major advantages to upper management of having a positive database administration function, as implemented by a strong database administrator follow.

The controlled database environment that is managed by the database administrator helps to assure efficient performance and increased operational reliability in the manipulation of data. This can promote data integrity, encourage standard data usages, enforce security safeguards, ensure controlled accessibility, and balance conflicting requirements. Application of the multiple tools that are part of the database administrator's tool chest can improve the utilization of the database.

The uniform database monitoring that is accomplished by the database administrator and his staff can facilitate a total organizational overview of all of the data resources. It can help in managing the growth and changes that occur in the database by ensuring that such growth is antipated and controlled. The optimization of database utilization can result from the enforcement of shared data resources. Any required reorganization, redesign, and restructuring activities associated with the database can be performed centrally for the entire organization simultaneously.

3. Personnel Reorganization

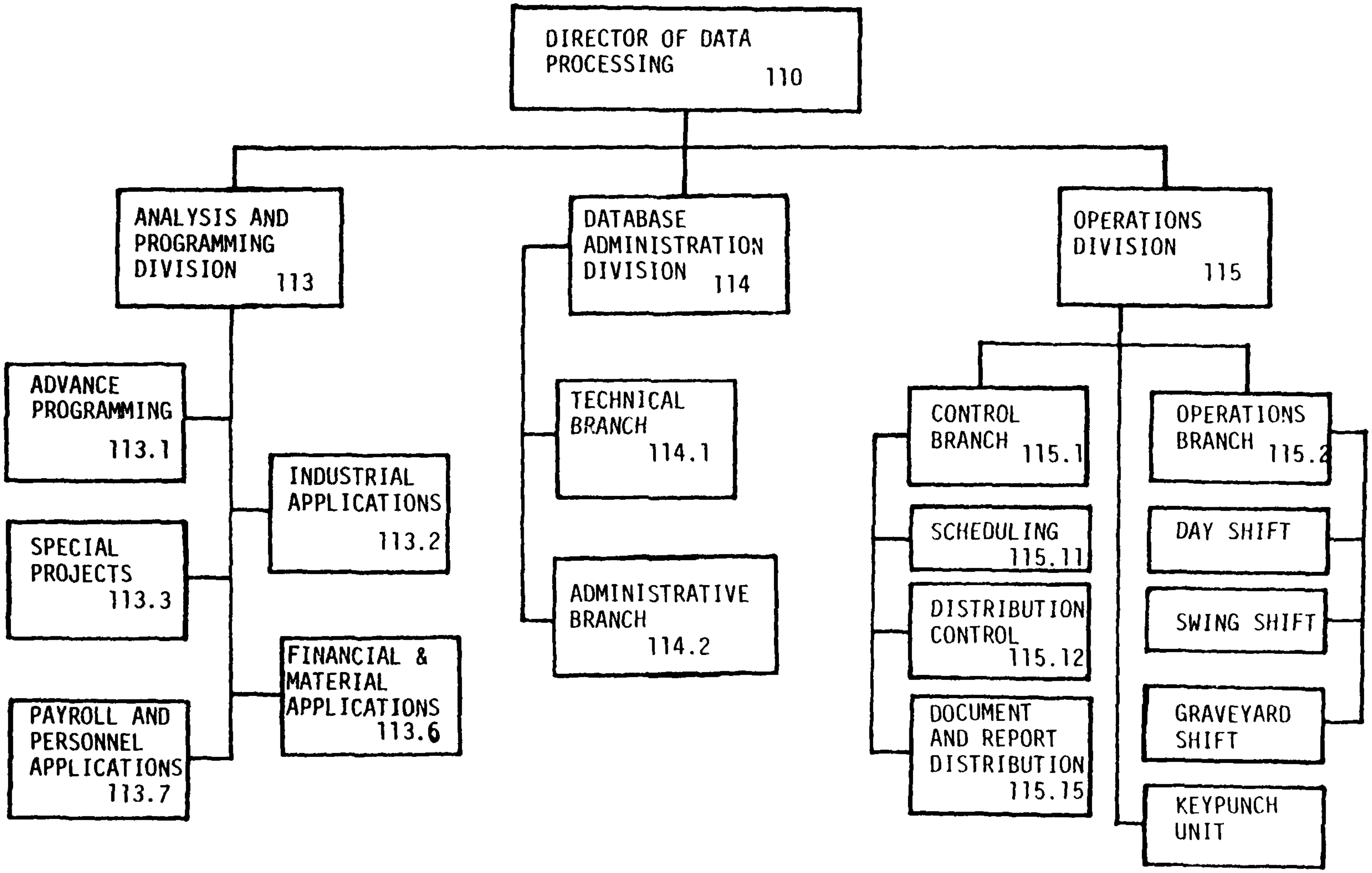
Since database administration is primarily a human function, its influence is affected by its placement within the organizational hierarchy. The variety of opinions with respect to the optimal residence of a DBA leads one to conclude that there is really no perfect organizational placement for a database administrator. Each system's environment operates with distinct organizational characteristics and the decision as to where to place the DBA nearly always involves tradeoffs.

Three organizational entities with which the DBA must contend are: computer operations, which is concerned with operating equipment; computer system analysis, which is concerned with the analysis and design of user applications; and, the users, who are concerned with ease of access to, and completeness of, the database. Personnel in each of these areas primarily consider their own interests and make the placement of the DBA within any of these organizational units a questionable policy. The solution offered is to place the database administrator in a staff position, reporting directly to the highest manager responsible for data processing within the organization.

The organization of the Data Processing Office at Mare Island Naval Shipyard indicates a logical location for the placement of the DBA within that hierarchy. Inserting the title of "Database Administration Division" and a functional code of 114, the DBA will acquire the appropriate organizational niche. The pay grade of the data base administrator himself should be equal to that of the Operation Division Head, GS-12 (Government Standard level twelve). Staffing of the Database Administration Division is accomplished by employing two GS-9s and four GS-7s as heads and staff members of the "Technical Branch" (Code 114.1) and "Administrative Branch" (Code 114.2) respectively. The recommended reorganization of Mare Island's Data Processing Office is summarized in figure 20.

The keypunch unit currently employs two shift supervisors, GS-6, three team leaders, GS-5, and twenty-three data transcribers, GS-3/4.

Figure 20 DATA PROCESSING OFFICE - REORGANIZED



These personnel are distributed roughly evenly between the daytime and swing-shift operating periods. With the implementation of the automated inputs associated with distributed processing, the following reorganization of these personnel would occur: both supervisors and one leader would become computer operators or technicians, one per shift; and, seventeen data transcribers would be transferred to the distributed data processing sites and retitled "Data Input Technician", thus eliminating the need for the distributed processing sites to provide an individual dedicated solely to keyboard operations. The remaining six data transcribers and two leaders would retain their present capacities since some keypunch requirements would undoubtedly remain. No other reorganization of the Data Processing Office is needed since the requirements and functions of the overall Shipyard Management Information System would not change under a DDP configuration.

F. DATA BASE MANAGEMENT SYSTEM

The responsibility of defining the content and structure of the data base and assigning data access and modification rights belongs to the database administrator. The data base management system (DBMS) is that element within the tool chest of the DBA that provides an integrated source of data for multiple users, while presenting different views of the data to different users. It can be characterized as generalized software which provides a single flexible facility for accommodating different data files and operations, while demanding less programming effort than conventional programming languages. Since the general orientation of this chapter has been toward maintaining compatibility with the Honeywell 6060 Information System currently in use at the Mare Island

Naval Shipyard, the Honeywell Integrated Data Store/II (IDS/II) data base management system will be described as the system of preference for employment in the distributed data processing system.

1. IDS/II Description

Honeywell's IDS/II is a generalized database management system which operates on the CALL level, with programs written in COBAL-74, and permits users to create, maintain and retrieve data [25]. On-line users interact with IDS/II through an interactive language which provides a wide variety of data manipulation verbs. IDS/II will run on the Honeywell Series 6000 Information System, of which MINSY's 6060 is a member, as modified by an extended instruction set. Minimum main storage for IDS/II is 128K words, which includes the storage requirements for the GCOS operating system.

IDS/II employs a linked list using both forward and backward pointers and hierarchically structured files consisting of fixed and variable length records. When declaring the data base, users may specify that it be logically constructed as network, hierarchical, chained or a combination of these. The physical organization may be sequential, indexed-sequential (ISAM), or random. IDS/II maintains this separate physical and logical view of the data structures to allow record and data placement on the storage media to be essentially independent of the associations and relationships among those records. Facilities are provided for storing and locating records directly, through a key field embedded in each record, or relatively through its current location in its chain. Both hierarchical and network data structures are supported as a by-product of the record linking and chaining techniques.

A high-level of data security is offered by IDS/II which allows users to assign passwords down to the field level. Data integrity is also to the field level which enables changes to be made to the data base without recompiling the applications that may employ them. Further data integrity is enhanced through systems journalization, automatic restart, and automatic recovery capabilities.

2. Data Base Structure

An Integrated Data Store/II data base is described in terms of three main types of entities: a schema (global) definition of all data structures in the data base, their logical associations and interrelations, and their primary storage and retrieval attributes; one or more subschemas or definitions of subsets of the schema that are accessible by application programs; and, area definitions that describe the mapping of the schema and subschema data structures to physical data sets. At the elemental data levels, an IDS/II data base comprises records and sets. A record is a named collection of data items indicating both the primary access method through which record storage and retrieval will be done, and the record occurrence to area mapping attributes. A set is a named collection of records which have a logical relationship. One record-type is defined as a set OWNER, while a second record-type is defined as a set MEMBER. Set relationships can be built to form hierarchies, simple and complex networks, and cycles. Structural linkages of set members can be used to provide secondary access paths to records.

Primary access paths to a given record are a function of its LOCATION MODE, the method by which it is entered onto the data base. Records are first stored in and retrieved from a data file, each record is then assigned a unique data base key which represents its storage location relative to the start of the data base. Each record defined for the schema must describe its location mode by either a DIRECT, CALC, or VIA set-name. Records defined as having a DIRECT location mode are assigned a data base key by either the Data Base Control System (DBCS) or the user. The user to DBCS interface is through a parameter in a user work area. CALC location mode records are located by virtue of a transform algorithm that uses values contained in specified data fields of a record to produce a header address. VIA set-name location mode records are stored as close as possible to their owner record within the data base.

3. Data Description

Data description is effected through three media: schema and subschema Data Definition Languages (DDL) and a Device Media Control Language (DMCL). The schema DDL describes data base content such as physical record structure, access methods, privacy constraints, data items and their attributes, and set relationships; the schema thus defines the global data base. The subschma DDL defines subsets of this global data base and provides the user interface with the schema. The DMCL describes the storage space areas and their page sizes. Each of these is to be controlled, maintained, and implemented by the database administrator.

The DBA implements each of these elements separately from any intended using program. The schema is developed first graphically, then translated into a series of global DDL statements, compiled, and entered into a data element dictionary and schema file. A similar sequence is followed for the DMCL. Subschemas are developed for the using programs, compiled, validated against the schema, and entered into a validated subschema file. Associated with all definitions (schema, subschema, and area) are privacy locks which can be further strengthened through password controls established at the general comprehensive operating system and file maintenance supervisor levels.

4. Data Retrieval

Data accessing is through a subschema declarative that is incorporated into the data division of a using program's COBOL-74 source deck. During compilation, a user work area is created and the subschema linkage data is compiled into object code. At execution time, a check is made to determine if the proper subschema has been compiled, validated, and translated in logical sequence. The using program is then linked with the subschema object file, and necessary control references are provided. During processing, data pages are read into internal buffer regions, which may be either pooled or distributed on an area basis. The subschema may declare that the data items of any record format be ordered in a fashion convenient to the using program. The data content itself may be transformed to a format convenient to the using program through ENCODE and DECODE functions. A full word of binary data within the data base will thus be represented to various using programs as packed decimal or ASCII character string data.

Communication between the using program and the Data Base Control System (DBCS) is accomplished through various registers and flags, and through the system's Data Manipulation Language (DML). At any point during processing, the user is able to receive the current status of all database functions relative to the program. He will know which area is current, which set and record name is current, and the status of a requested DML function. Data base keys are related through communications registers and privacy locks supplied to the DBCS through a defined register. Privacy locks may be declared to disallow access to a record, or to disallow specific DML functions for a subschema unless the lock's key is supplied. Records may be retrieved, stored, inserted, removed or erased from a set if the proper privacy locks have been cleared.

A FIND is included in the data manipulation language which permits record-selection expressions based on structural conditions existing in the data base such as find next-in-path, and find record-name within a set or area. Other IDS/II interactive data manipulation verbs include: ACCEPT, CONNECT, DISCONNECT, ERASE, FINISH, GET, LIST, MODIFY, MOVE, READY, REPEAT, SET, STORE, and USE. The ACCEPT and SET verbs provide data base key manipulations. FINISH and READY provide area preparation statements. USE invokes any embedded data procedures in DBCS required for a current operation. The remainder of the verbs perform record and data manipulative functions. Boolean, comparative, or relational operations must be performed through host facilities of COBOL-74.

G. EQUIPMENT ORGANIZATION

Previous portions of this chapter have delineated problems associated with the current Shipyard Management Information System as it is employed at Mare Island Naval Shipyard. Compatibilities which exist between distributed data processing and MIS philosophies have been described which have led to the implication that DDP fulfills MIS managerial requirements. The need for, and benefits of, a database administrator to be responsible for the management of the data base have also been presented. The method by which personnel of the Data Processing Office will be prepared for the new processing procedure and the relatively minor reorganization necessary within this office have also been related. For sake of brevity, it has been assumed that permission has been received to implement distributed data processing and to acquire DDP equipment that is compatible with the Honeywell 6060 information system. What remains, then, is to describe the equipment organization that will be required to construct a distributed data processing system at Mare Island Naval Shipyard.

1. Network Configuration

There are three commonly used methods of distributing the data base to satisfy the requirements of a distributed management information system [26]. These processing configurations are known as star, hierarchical, and ring networking. Each of these methods has inherent advantages and disadvantages. However, since this analysis is tasked with retaining the 6060 system as a basis for distributed extensions, the overall network configuration to be implemented is also constrained by this requirement.

a. Hierarchical Configuration

The hierarchical configuration is a viable means of implementing the data base. Within this configuration, the system consists of a host computer followed by an arrangement of lesser machines until a terminal level is rached. The primary advantage of a hierarchical configuration is that it provides distributed computing power. This configuration is also quite suitable for implementing heterogeneous nodal processing systems. Although there are no inherently obvious major disadvantages to this configuration technique, one characteristic eliminates it from further consideration: since a desired theme is system homogeneity and standardization, and since heterogeneous nodes require additional translation processes to make them interact smoothly with the overall system, this becomes a future development for MINSY and not to be considered here.

b. Ring Configuration

A ring configuration is the ideal of the distributed processing purist. All data is distributed; no redundant data exists; and, nodes share data through a common link. Ring configuration provides autonomous processing nodes without redundant data, which is ideal as long as the system remains sound. If a break occurs in the ring, no backup is available unless a redundant ring is installed, resulting in demise of the entire system, especially if the failed node holds an important portion of the data base. The DBA must devise an updatable directory to identify where specific information is located around the ring and then place it where it is accessible to all nodes. A solution to both problems is to connect the processing nodes to a central host which could contain both the directory and the backup data base. This leads to the configuration of choice, the star configuration.

c. Star Configuration

The star configuration is similar to the commonly used centralized data base concept. This system consists of: a host computer that contains a central data base, controllers, and the common data access method; and, node processors consisting of minicomputers and relevant portions of the distributed data base. This centralized system provides tight control over data, ensures data security, provides a common file accessing technique, and provides a common data base logical structure.

A major problem associated with this configuration is data unavailability due to file usage or line loading. A way of overcoming this is to distribute copies of the appropriate data to the concerned processing nodes thus eliminating delays due to line loading or use by other nodes. This does result in data redundancy and some loss of control in terms of directory maintenance, however, the benefits of backup and shareability offset those disadvantages. By retaining a master copy of the data base locally, the database administrator is able to exercise control over its content, organization, and security. Redundancy enhances backup and shareability since the central system is able to continue servicing other nodes requiring data from a failed node.

If the failure of a node is due only to a communications breakdown, the node will continue to service local users. This continued processing does compromise the integrity of the data at the central site which is only as current as the last input from the nodes. A highly dynamic MIS cannot tolerate a prolonged nodal failure. A solution is to permit normal processing to be on a query-only basis, where not all data would be as current as possible, with all updating done during off-hours. Since batch processing is currently handled this way at MINSY, no major changes in operating procedures would be required to implement this technique.

2. Honeywell Level-6 Minicomputer

A primary ingredient for distributed processing, alluded to throughout this presentation, is the implementation of computing power and data storage for a specific application within the Shipyard MIS at a dedicated processing node. This node must be able to interface with the host Honeywell 6060 system through the installed DATANET 355 Front-End Network Processor. The Honeywell Level-6 Minicomputer family is suited to fulfill those requirements. Level-6 architecture is based on a twenty-four-bit-wide universal bus called the Megabus. The CPU attaches directly to the Megabus using controller boards, which give Level-6 a modular architecture. Up to four device or memory pacs, a Honeywell term for dedicated modules, fit on one controller board. Since the memory and peripherals are attached to the sane bus, all data is transferred using direct memory access [27].

a. Central Processor

All Level-6 processors use a microprogrammed architecture with a transistor-to-transistor bipolar logic (TTL) and a sixteen bit word length. Standard features for Level-6 processors include sixty-four firmware-controlled vectored priority interrupts, extended instruction sets, flexible word lengths, hardware multiply and divide, a real-time clock, a ROM-based boostrap loader, and ROM-based diagnostics.

Most hardware registers are sixteen bits in length except for the mode registers which are eight bits long. Within this framework, the CPU can process double words (thirty-two bits), words (sixteen bits), bytes (eight bits) or single bits. Floating point values can be two or four words. The Level-6 uses two types of data: signed data is used in arithmetic operations; unsigned data is ued for logical quantities, addresses, or ASCII characters. Unsigned data is expressed in hexadecimal notation while signed data is represented in two's complement notation.

The basic set of 106 instructions include: bit instructions for testing, resetting, and complementing addressed bits; byte instructions for logical arithmetic operations; and word and multiple word instructions for handling data of variable size. Single and double-operand instructions manipulate the data in registers and memory; short-value immediate instructions manipulate data in the general registers. There are thirty-two branch and branch-on-indicator instructions, twelve shift instructions, three I/O instructions, and fifteen generic instructions.

Sixty-four multiple vector interrupt levels can be priority programmed by the user and implemented by firmware through the Megabus. Interrupt levels for each controller can be dynamically set by software before each job or before each peripheral instruction sequence. The CPU determines from the assigned interrupt level whether a board can interrupt, and the order in which interrupts will be honored. The processor can receive an interrupt request at any time, including the time between the two cycles of a read operation. However, the interrupt is not processed until the instruction has been completed.

b. I/O Control

All input and output for Level-6 minicomputers occur over the Megabus using direct memory access (DMA) transfers. The Megabus is an asynchronous, bidirectional bus with a transfer rate of six mega-bytes per second and a cycle time of 300 nanoseconds. The bus is fast enough to allow many I/O operations to be multiplexed. Multiple I/O units can multiplex on a word basis to the same memory unit as long as the combined data transfer rates do not exceed the maximum memory transfer rate of 1.1 million words per second. Three intelligent peripheral controllers are provided: the Multiple Device Controller, Mass Storage Controller, and Magnetic Tape Controller. A general-purpose DMA interface for user logic is also present.

c. Peripherals

Honeywell supplies a broad range of low-speed peripherals and high-speed units in addition to a number of terminals. All peripherals interface through device pacs (modules) on the individual controller boards which connect to the Megabus. Level-6's low-speed devices (card readers) card punchers, serial and line printers) are supported by the Level-6 Operating System and require device pacs that fit on the Multiple Device Controller. High-speed peripherals are also supported by the Level-6 Operating System; magnetic tape drives require a device pac for each drive and one magnetic tape controller for every four drives; up to four large disc packs are supported by one device pac and one Mass Storage Controller. Teletype-compatible CRTs and teleprinters are supported by the GCOS-6 software and interface to the Megabus through the Multiple Device Controller or through the Multiline Communications Processor.

d. Data Communications

The Multiline Communications Processor (MLCP) is the hardware basis to Level-6 data communication capabilities. The MLCP board has a microprocessor with 3,072 words of RAM that the user can program for his own line handling and protocols with the help of MLCP software. The on-board microprocessor delimits the data stream and offloads the CPU of character generation, error detection, and the clock-check function. Maximum throughput is twenty-four thousand bytes per-second. The MLCP holds up to four line adapters of any mix of synchronous, asynchronous, broadband, or current-loop connection communication pacs.

MLCP software is supported under the Honeywell General Comprehensive Operating System. GCOS-6 supports synchronous and asynchronous protocols, and communications features including a subset of the IBM 2780 bi-synchronous protocol. Two communications utilities are available under GCOS-6: Data Entry Facility (DEF) is a data-entry forms package; and, Remote Batch Facility (RBF) allows the Level-6 processor to be used as a remote batch station for the host processor.

e. Software

Honeywell provided software for the family of Level-6 minicomputers includes operating systems, language processors and a wide range of utilities. The GCOS-6 operating systems are multi-tasking, multi-user disk-based operating systems. Source and object text programs of the Basic Executive System (BES) can be run under GCOS-6. Five major languages are available for the Level-6: assembler with macro preprocessor, FORTRAN, COBOL, BASIC, and RPG. GCOS-6 and BES operating systems utilities include the options of Sort/Merge, DEF, and RBF.

(1) Operating System. As a full diskette-based real-time software system, GCOS-6 has extensive executive, file management, and communications facilities, and a wide complement of development software. The GCOS-6 executive concurrently executes one batch stream (program development or other user application) and a number of on-line user application job steams limited only by the amount of available memory.

Batch applications can be rolled out to a mass storage device in order to obtain more memory for on-line applications.

Operators communicate with the operating system through four control languages: System Generation, Execution Control, Operator Control, and Monitor Control. The System Generation Language is used to develop system generation directives from a set of directives supplied with the operating system. The Execution Control Language controls all task groups, enables users to submit batch requests, handles file-related functions, and handles the execution of all utilities. The Operator Control Language allows the operator to control on-line task groups, batch streams, and device assignment. Macro calls of the Monitor Control Language allow the user to perform monitor functions with an assembler language program.

The GCOS-6 tree-structured file system provides different file systems for each of the supported I/O devices. It provides four file organizations for discs - sequential, relative, indexed, and fixed-relative. Sequential access is provided for magnetic tape, communications, and all unit record devices. Files can be accessed by COBOL, FORTRAN, RPG, or assembler language statements. GCOS-6 requires a CPU with thirty-two thousand words of memory, one cartridge disk unit, or four diskettes, and one terminal.

(2) Language Processor. GCOS-6 (entry level) COBOL is based on ANSI COBOL-74 standards. This COBOL level requires thirty-two thousand words of memory. Extensions include support of file handling for sequential, relative, and indexed files, three-dimensional tables, CALL and CANCEL capability, DISPLAY and COMPARE data, full American National

Standard editing, and twenty-one additional verbs. GCOS-6 (intermediate) COBOL, also based on ANSI COBOL-74 standards, provides facilities for reentrant programs, packed decimal and thirty-two-bit signed binary data types, and the callable Sort/Merge utility. Even though other languages are supported by GCOS-6, only the COBOL language has been further amplified since that is the language of use at Mare Island's Data Processing Center.

(3) Utilities. The Sort/Merge utility for GCOS-6 features up to sixteen sort-key files of ASCII or numeric data; the output sequence is based on ascending or descending sequence by key: a temporary work file can be created and automatically deleted later; the BES Sort accepts control fields of up to eight keys per record with a maximum single key size of 356 bytes and a maximum record size of 512 bytes. The Data Entry Facility of the GCOS-6 utility for form creation supports up to twelve terminals and up to six line or serial printers; the DEF package is able to execute simultaneously with the GCOS operating system. The Remote Batch utility allows the Level-6 to be used as a remote batch terminal to the host computer while still performing its own on-line processing; the host computer is interfaced by Remote Computer Interface protocols.

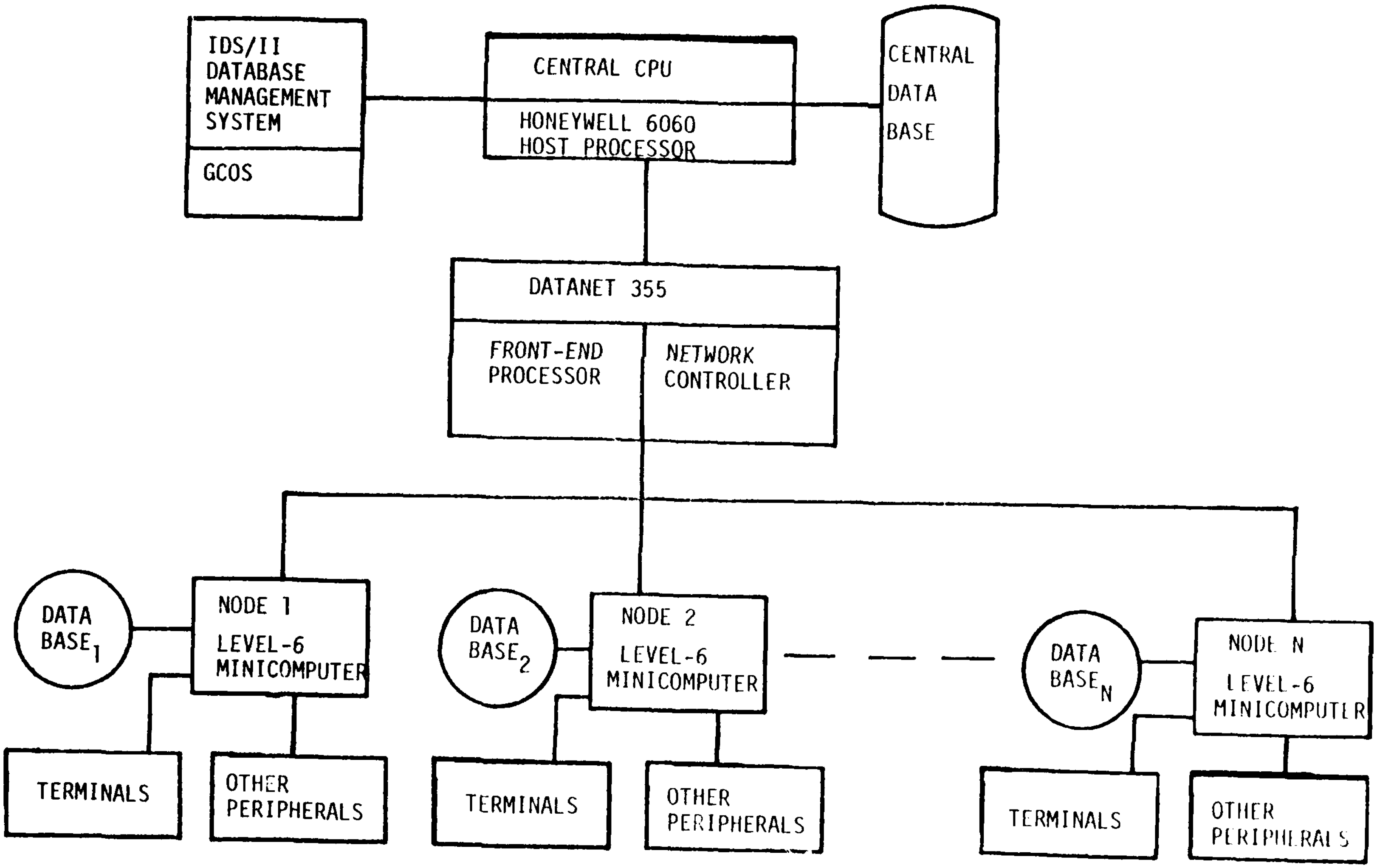
3. DDP System Architecture

The architecture of the distributed data base system at Mare Island Naval Shipyard must closely resemble the representative DDP system as presented earlier in figure 3, of chapter I, and as constrained by the 6060 system already in use. The Honeywell 6060 system is to remain as the host processor and contain the central CPU. The central data base remains resident within MINSY's Data Processing Center. The Integrated Data Store/II database management system is to be incorporated into the overall system. The DATANET 355 Front-End Network Processor provides a controlling function for the Level-6 Minicomputers that are to be installed as node processors. Each Level-6 site contains the data base and full rnage of peripherals relevant to that particular subsystem or application mode that the node is dedicated to serve. Figure 21 portrays this overall system.

Whether or not a location that is a candidate site for a distributed node receives a Level-6 Minicomputer with its full range of dedicated databases, input and query permissions as well as peripherals, a CRT and keyboard for query-only, or a CRT and keyboard including input as well as query permissions, is dependent upon: its relative importance in the shipyard organizational hierarchy; the amount of information it requires to efficiently perform its function; the number of transactions it generates; and, the volume of data that is inherent to its functional application within the Shipyard MIS. Initially, the following six functional areas within MINSY should contain a Level-6 Minicomputer with its full range of databases, input and query permissions, as well as peripherals: the Planning, Production, Supply, Comptroller, and Administrative Departments, and the Data Processing Office. Offices that will be allowed query and input functions will be connected to the relevant Level-6 application they serve. Inputs will be allowed only to the files for which a specific terminal is responsible. Query-only terminals are to be connected to the specific Level-6 function to which they refer, but may access the central data base and other nodes for information that is

Figure 21

DDP SYSTEM ARCHITECTURE



required in the performance of the duties of the area in which they are resident. These initial connections are summarized in figure 22. It will be the responsibility of the requesting department head in liaison with the Management Engineering Office and the Database Administrator to decide on the placement of Level-6 Minicomputers and terminals throughout Mare Island Naval Shipyard.

Figure 22

DDP SITES

FULL LEVEL-6 MINICOMPUTER OPERATIONS	PLANNING	PRODUCTION	SUPPLY	COMPTROLLER	ADMINSTRATION	DATA PROCESSING
INPUT AND QUERY PERMISSIONS	COMBAT SYSTEMS DESIGN ESTIMATING FORECASTING	ALL PRODUCTION SHOPS CONTROL BRANCH QUALITY ASSURANCE TEST DIVISION	DMI CONTROL MATERIAL CENTERS PURCHASING TOOL ISSUE	BUDGETING COSTING PAYROLL TIME-CLOCK STATIONS	INDUSTRIAL RELATIONS PLANT ACCOUNTING PUBLIC WORKS RADIOLOGICAL CONTROL	
QUERY-ONLY PERMISSIONS	FBM CONTRACTORS RECORD CENTER SHIPYARD COMMANDER	REPAIR OFFICER SHIP SUPT. SHIP WORK CONTROL CENTER TYPE DESK	FBM MATERIAL	AUDITS CONTRACTING STATISTICS	SAFETY SECURITY	MANAGEMENT ENGINEERING

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